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Mango Value Chain Development Strategy

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Abstract:

Significant opportunities exist to strengthen the Pakistani mango industry and further develop market opportunities for both fresh and value-added mango products. However, this will require overcoming numerous constraints in mango production practices, harvesting methods, postharvest care, transportation, and marketing. The objective of the Firms Project mango sector development strategy should be multi-faceted in terms of market penetration and products. All Project activities should be market driven, with the goal of providing consistent supplies of high quality fresh and agro-processed mango products at competitive market prices. Further development of the export market for Pakistani mangoes represents the area of greatest potential economic impact in the FIRMS Project targeted districts. Penetration of the major retail supermarket chains in the Middle East, E.U., Asia, and North America should be prioritized. Retail marketing channels typically provide growers/exporters with higher returns compared to wholesale marketing channels. The retail market channel, specifically the major supermarket chains, constitutes the majority of produce item purchases among consumers in Europe and North America. The supermarket sector is also becoming increasingly strong in the Middle East and Asia. Significant improvements in production and postharvest handling practices will be necessary in order for mango suppliers from Pakistan to be competitive in the international marketplace. Good agricultural practices must be adopted by growers and the final marketable product must adhere to higher quality standards over currently accepted norms in the domestic market. Global GAP certification for producers and HACCP programs for agro-processors will have to be adopted for fresh and agro-processed mango products in order to penetrate mainstream retail markets in many international destinations. World markets are demanding implementation of strict food safety and product traceability programs.

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Executive Summary

A number of mango-related activities are suggested during the next 4 years of the Firms Project. The initial activities should focus on establishing additional export markets by linking potential importers/buyers with producers/exporters capable of supplying the desired fresh or value-added mango product. A multitude of training, technical assistance, infrastructure procurement, and human resource capacity building activities should follow. These activities should target overcoming existing constraints in the mango supply chain. There are many weak links in the production, postharvest handling, and agro-processing supply chain of Pakistani mangoes. The weak links include improper irrigation practices, inadequate tree nutrition, lack of tree pruning, inadequate pest management practices, improper harvesting methods, inadequate postharvest care, weak packaging, and lack of cooling and proper temperature management. The end result of all of these constraints is a high degree of variability in product market quality. This is not acceptable to importers providing fresh or processed mango products to international retail markets. These importers require consistent supplies of uniformly high quality mangoes.

Although some producers follow acceptable production practices, the vast majority of producers are not aware of the most appropriate and modern crop care techniques to use to optimize yield and market quality. In order to fill this knowledge gap, both at the producer and agriculture extension agent level, the Firms Project should provide technical assistance and training conducted by a combination of project staff, international experts, and local specialists. Information dissemination should involve multiple venues, including workshops, intensive short courses, detailed mango production and postharvest care guides, Web-accessible information updates, benchmarking study tours, and market linkages, etc.

Development of high-value markets and new value-added mango products should be the underlying objective of the Firms Project mango sector activities. The following markets and products should be given priority during the next 4 years: fresh mangoes for the leading retail supermarkets in Europe, Asia, and North America; mango pulp, nectar, and drinks; dried mangoes; and individual quick frozen (IQF) mango products. All have strong potential for further market development and are lacking or under-represented by Pakistan in the global marketplace.

Market linkage activities should begin as soon as possible, linking potential importers/buyers with producers/exporters that are capable of supplying the desired fresh or value-added mango product. An international workshop in Multan, linking representatives of the leading mango importing companies in the U.K./E.U., is suggested for early winter, 2010. This should be complemented by participation of Pakistani grower/exporters at the Fruit Logistica produce marketing conference in Berlin, Germany for further market linkages between the GlobalGAP-certified producers and potential importers. Pre-arranged meetings between potential E.U. importers and

Pakistani producers/exporters should be set up in advance of the produce conference to facilitate meeting with as many potential importers as possible. Identification of potential market opportunities will give producers an incentive to invest in the appropriate technologies and infrastructural improvements required to supply the market with high quality mangoes

1. Introduction

The USAID-funded Firms Project is designed to help Pakistan achieve the capacity for sustained, higher economic growth rates that are private sector-led, employment generating, and equitable. The objective of Firms is to improve government service delivery and develop dynamic, internationally competitive firms in target districts to accelerate sales, investment, and job growth to provide alternatives to and forestall extremism by working through Pakistani organizations. The Firms Project will provide technical assistance, training, commodity support, and grant activities in order to accomplish its goals.

Mangoes are the second leading fruit crop produced in Pakistan, with an annual production volume of 1.7-1.8 million metric tons (Agricultural Statistics of Pakistan). Pakistan is the fifth largest producer of mangoes in the world. The main production province for Pakistani mangoes is Punjab, with 65-70 % of the total volume produced. Sindh is the second leading province, with 30-35 % of the nation's total production.

Strengthening of the mango industry will have a major impact on the economies of the targeted production and agro-processing districts, along with agri-business related activities throughout Punjab and Sindh provinces. Job creation, income generation, and employment opportunities for women will be the positive benefits of a robust and expanding Pakistani mango industry. Significant market opportunities exist both domestically and internationally for those mango producers and agro-processors that can provide consistent supplies of high quality fruit and value-added products. However, international fresh and agro-processed mango markets are very competitive. It will be necessary for the public and private sector stakeholders in the Pakistani mango sector to make significant improvements in production practices, postharvest care, packaging, and transportation technology in order to compete successfully with other mango supplying countries. It will be necessary for the Pakistani mango sector to modernize its production practices and postharvest care in order to maximize potential yield and fruit quality. This will require investments in applied research and on-farm packinghouse and cooling infrastructure.

It will be imperative to change the international perception of the Pakistani mango from one of variable and inconsistent quality and low price to that of uniformly high quality and high value. The mindset of the mango producer must also change from one limited care and investment to that of high care and substantial investment. Producers and exporters will need to modernize their technologies and invest in infrastructure to be globally competitive. It will also be imperative for producers to significantly improve their cultural practices in order to optimize yield and fruit quality. Specifically, it is essential to reduce the amount of anthracnose and stem-end rot disease inoculum on the skin surface. These two fungal diseases are the most serious postharvest decay problems in mango, although the infection process occurs as the fruit is developing on the tree. In addition, the postharvest handling practices will have to be improved to reduce the

amount of fruit decay. Hot water (52° C for 3-5 minutes) and fungicide treatments can be very effective in minimizing postharvest deterioration. In addition, rapid cooling of the fruit after the hot water treatment, followed by maintenance of the cold chain at 12-13° C during transport and distribution to market is necessary for proper arrival quality of the fruit in the destination market.

Firms Project success in helping to further develop the mango sector will be achieved only if the activities are based on market driven realities. Therefore, it is important to identify potential market outlets prior to making significant investments in time and resources for the various fresh and agro-processed mango products. The FIRMS Project should also focus its resources toward working with the progressive mango growers who are committed to investing in their own operations.

1.1 Objective

The objective of this assignment is to design a coherent 4-year strategy and work plan, which if successfully implemented, will result in Pakistani mangoes becoming a force in the international marketplace.

1.2 Tasks

The assignment involved multiple meetings and site visits to representative public and private sector stakeholders in the mango value chain. Multiple visits were made in Lahore, Multan, Karachi, and Islamabad to obtain a more detailed understanding of the opportunities and challenges confronting the mango sector. Numerous growers, processors, and exporters were interviewed. Two stakeholders meetings (August and October) of mango producers were also held in Multan. Valuable input was obtained to facilitate the development of an overall Firms Project mango sector strategy that will enable the industry to become more competitive and sustainable.

2. Constraints Facing the Mango Sector and Project Strategy Recommendations

Numerous constraints will need to be overcome in order to strengthen the Pakistani mango sector and make it more competitive in both the domestic and export market. Improvements and innovations are needed all along the value chain, including numerous production practices, pest management programs, harvesting methods, postharvest technologies, value-added agro-processing, marketing, and training/technical assistance to producers, packers, and agro-processors. Significant infrastructure investments are also needed in on-farm grading, packing, cooling, and cold storage equipment to extend mango fruit market life and preserve the postharvest quality. Firms Project activities should address each of the constraints in an integrated manner in order for fresh and agro-processed Pakistani mango products to be more competitive in the global marketplace. This will be realized only when the mango industry is able to provide consistent supplies of uniformly high quality fruit and value-added fruit products. Quality begins with the use of proper production practices during the growing season and continues after harvest to include all the appropriate postharvest care practices to maintain product quality during temporary storage, packing, and transport to market.

Substantial technical assistance and training is needed to increase the knowledge level of the producer and the agriculture extension specialists who support the mango producers. Growers must be provided with adequate knowledge on proper production practices, harvesting methods, postharvest care, and marketing. Human resource capacity building and workforce development needs considerable strengthening in order for the Pakistani mango industry to be more competitive. The Firms Project training and technical assistance efforts should build on the existing initiatives of the mango supply chain management project being implemented by the Australia-Pakistan Agriculture Sector Linkages Program (ASLP) and the farmer field school training program provided by the Government of Punjab Agriculture Department. It is very important that the Firms Project complement, and not duplicate, past and on-going project efforts which support the mango value chain. Nevertheless, more training, technical assistance, and applied research by the provincial and federal agriculture institutions, donor agencies, and private sector is needed to overcome existing constraints in the mango crop value chain.

Market intelligence is one of the foremost constraints facing the Pakistani mango sector. This includes awareness of prices, alternate market opportunities, and linkages with domestic, regional and international buyers in order to obtain more profitable returns. Currently, the majority of the mango volume marketed in Pakistan is sold to

intermediary contractors and commission agents who procure the fruit from the owner prior to harvest at less than optimal prices.

In general, the Pakistani mango industry suffers from a lack of modernization and investment in appropriate technologies. Minimal change has occurred in the production, harvesting, and postharvest handling practices for Pakistani mangoes over the last several decades. The cultivars being grown, nursery stock quality, production practices, harvesting methods, packaging materials, postharvest care, agro-processing, and marketing is similar now to a decade or two earlier. This stagnation in technology advancement has not allowed Pakistani mangoes to become established in high value international retail market channels.

The most important constraints facing the mango sector are discussed below, followed by recommendations for Firms Project activities to overcome these constraints.

2.1 Planting Stock

An important constraint Pakistani mango growers face is the lack of availability of disease-free certified nursery stock and genetically-uniform rootstock/scion planting stock. The yield and fruit quality of genetically uniform, disease-free planting stock is superior to heterogeneous, disease-infested planting material. Furthermore, mango growers are not aware of, nor have access to, the cultivars of mangoes that have strong international market demand. These include the highly popular Keitt, Kent, and Ataulfo cultivars, which are highly popular in Europe and North America. These cultivars are being grown commercially in other countries with similar agro-climatic conditions to Punjab and Sindh provinces. Addition of these cultivars to the portfolio of Pakistani mango offerings would complement the existing cultivars and further strengthen Pakistan's ability to provide the global market with a diversity of high quality fresh mangoes and agro-processed products.

Recommendations

The Firms Project should provide technical assistance and training to existing and new plant stock providers on how to establish and maintain a genetically-pure and disease-free nursery operation. Linkages should be established with mango nurseries in other countries in order to help facilitate the process of introducing mango cultivars with strong international demand for trial in Pakistan (i.e. Keitt, Kent, Ataulfo).

2.2 Soil Preparation

Mangoes prefer well-drained soils of medium texture (silt-loam), high in organic matter, with a pH between 6.5 to 7. It is important the soil be properly prepared before tree planting, as making alterations in the soil after transplanting will be difficult. The pH of most soils in Punjab and Sindh provinces is alkaline (>8) and not ideal for optimal tree fruit growth. Microelements are less available for plant uptake under alkaline pH's and

deficiency symptoms of iron, manganese, boron, and other nutrients was observed during the field visits in Multan.

Soil pH can be modified by incorporation of sulfur prior to planting, which will improve the health and vigor of the mango trees. Soil salinity is another common constraint to realizing optimal mango yields. The salt concentration in the soil can be lowered by periodic leaching. In addition, the liberal incorporation of organic matter in the soil prior to tree planting will improve the nutrient content and water holding capacity of the soil. Organic matter will also help to reduce salt stress. Prior to tree planting, growers should analyze their soil for pH, salinity, % organic matter, and nutrient content.

Recommendations

Easy-to-use, rapid, and accurate soil monitoring devices are available for growers to use to determine soil pH, salinity, and concentration of certain nutrients. The use of these devices should be demonstrated in the series of workshops and training sessions provided during implementation of the project. Fruit crops extension agents employed by the Government of Punjab should also have these devices for use during their field visits.

Soil testing (and plant tissue testing) facilities should be available for grower use at affordable prices. The Firms Project should help foster the development of this service in cooperation with the provincial government analytical testing laboratories, universities, or other public-sector institutions.

2.3 Irrigation

The most common type of irrigation used in Pakistan for mangoes is surface flooding. This is a very inefficient method of water application and also results in soil compaction and increased root rot disorders, including mango sudden death syndrome (SDS). Significantly better and more efficient methods of water application include micro-sprinkler and drip irrigation. These water application methods are standard techniques for mango production worldwide, but rarely used in Pakistan.

Recommendations

In order to maximize water use efficiency and conserve valuable water resources, it is highly recommended the mango sector adapt modern drip and micro-sprinkler irrigation practices. These irrigation methods can save over 50 per cent of the available water, increase mango yield, and improve fruit quality. Combined with the use of soil mulches, these water application methods will maximize water use efficiency. However, conversion from surface irrigation using canal water to drip or micro-sprinkler irrigation will be an expensive proposition. This will require digging a tube well and/or constructing a reservoir and pumping water out of this source. A pump and diesel will be necessary to deliver the water to the mango trees. Drip and/or poly tubing and/or micro-sprinkler delivery heads will also need to be purchased. Government subsidies are available to farmers for conversion from surface to drip irrigation, which are helpful in encouraging

the adoption of more efficient water application methods. Nevertheless, it is unrealistic to assume that this irrigation technology will be adopted by a significant number of mango growers during the life of the Firms Project. Currently, only one mango operation in the country is using micro-sprinklers as the main source of irrigation water.

Demonstration plots should be established at the Mango Research Station in Sujaabad and/or other appropriate Punjab and Sindh provincial government research facilities and on private growers land. The objectives should be to compare yield, incidence of SDS, and other tree characteristics between flood irrigation, under-tree micro-sprinkler, and drip irrigation on mangoes. The Firms Project should help to facilitate these studies by providing an irrigation expert to help in the design and monitoring of the test plots.

2.4 Fertilization

The nutritional status of the individual mango tree strongly influences plant vigor, yield potential, and quality of the fruit. A common physiological disorder of mango fruit, jelly seed, is accentuated by nutrient imbalances (i.e. low calcium). It is important to know the soil fertility level, percent organic matter, and soil pH in order to apply the proper amount and balance of macro and micro-nutrients to the mango tree. Prior to planting, a soil fertility test should be done, to include analyses of the aforementioned parameters. The results from the soil test will provide the basis for the fertilization protocol and the need for soil amendments such as sulfur to lower the pH and organic matter to improve the soil texture prior to tree establishment. In addition, a combination of field test kits and laboratory soil/leaf tissue analyses should be used to monitor the nutritional status of the mango trees on an annual basis.

Recommendations

Training workshops should be conducted for agriculture extension agents and growers on the use of field instrumentation to check pH, soil salinity, potassium, and nitrate content. Training should also be given on how to properly take soil and leaf samples for nutrient analyses.

Demonstration plots should be set up on both provincial government research locations and private growers' mango orchards comparing different levels of macro and micronutrient fertilization on tree vigor and fruit yield. It is important to establish the correct fertilization schedule and quantity in order to obtain optimal yields and fruit quality. For example, internal pulp breakdown of the mango fruit (known as jelly seed) is problematic in areas with soil calcium deficiency and can be corrected with proper fertilization.

Illustrated guides on individual nutrient deficiency symptoms for mangoes should be published and provided to commercial growers and agriculture extension agents. In addition, the critical tissue nutrient concentration required for optimal growth should be included in these guides. The FIRMS Project should help to facilitate the dissemination

of existing research information to the mango growers and provincial government extension agents.

2.5 Tree Training and Pruning

Proper training of the limbs and branches of the young mango tree is critical to formation of the proper tree shape. The majority of tree fruit growers in Pakistan do not use proper tree training practices and the result is a poorly shaped tree with an undesirable canopy structure. Tree training practices should encourage early production and the development of a strong structural framework capable of supporting heavy crops in future years. The training program should also produce trees that will be easy to manage in later years. Ideally, mango trees should be trained in their formative years to have a central leader with 3 to 4 lateral branches growing at wide angles from the main trunk. This limb framework will allow for adequate light penetration and air circulation through the tree canopy. This will increase fruit yield and minimize disease incidence over narrow, more vertically-oriented branches. The main postharvest fruit diseases of mangoes are anthracnose and Diplodia stem-end rot, which are accentuated by poor air circulation and high humidity inside a dense canopy. Other diseases and insect pests are also difficult to control inside excessively vegetative canopies.

In addition to improper tree training, most mango growers do not prune their trees and the result is tall, excessively vegetative branch growth. This also makes it difficult to harvest the trees. The growth of the young fruit tree should be directed into branches that will be a permanent part of the mature tree. Superfluous growth should be pruned in order to minimize the expenditure of photosynthetic energy into useless branches and vegetative growth. Mango trees should be properly pruned on an annual basis. Proper pruning removes unproductive wood, maintains optimum vigor in productive wood, and encourages the continuous development of new fruit bearing wood. Considerable rehabilitation pruning of older non-productive orchards will be necessary to increase yield and fruit quality of the existing trees.

Recommendations

Technical assistance and training should be provided to growers and provincial government extension agents on proper mango tree training and pruning practices. Demonstration plots should be established in cooperating growers' orchards comparing the yield and fruit quality between different pruning methods. The FIRMS Project should help to facilitate the establishment of these test plots. In addition, the Firms Project should help to establish private sector tree pruning service providers, which will offer this service on a fee basis to growers that may not have the resources to manage their own tree pruning.

2.6 Pest Management

Numerous insect pests and diseases exist in Pakistan that can reduce the yield and market quality of mangoes. It is imperative for growers to adopt an integrated pest management strategy which uses a multi-faceted approach to pest control. This should include the planting of pest-resistant cultivars (if available), field sanitation, proper fertilization, irrigation, and pruning, predator insect establishment, and the use of crop protectants.

A disease complex endangering the mango industry in Pakistan is sudden death syndrome (SDS). It is thought to be caused by one or more soil-borne fungal pathogens and possibly vectored by insects. A combination of environmental stresses and disease organisms interact to weaken and eventually kill the trees. The disease is characterized by drying of twigs and branches followed by complete defoliation, which gives the tree an appearance of being scorched by fire. The onset of die back becomes evident by discoloration and darkening of the bark. The dark area advances and young green twigs start withering first at the base and then extending outwards along the veins of leaf edges. This disease can cause rapid mortality of well-established trees. Thousands of mango trees have been cut down in recent years due to severe attack of this disease. No cultivar has been found resistant to this disease and the problem is accentuated with excess flood irrigation and wounding of the tree roots. Replacement of flood (surface) irrigation with drip or micro-sprinkler irrigation is likely to reduce the incidence and severity of SDS.

Malformation is another pre-harvest disease that is prevalent throughout Punjab and Sindh provinces. It is a fungal disease caused by several species of *Fusarium*. It is usually associated with the bud mite, *Aceria mangiferae*, which has been shown to spread the disease within a tree, but not between trees. Other diseases that may be problematic include powdery mildew, leaf spot, and *Alternaria*.

Anthrachnose and *Diplodia* stem-end rot are the worst postharvest diseases of mango fruit in Pakistan. Spores of these fungal pathogens infect the fruit while developing on the tree, but remain in a latent or dormant state until after harvest. Symptoms of these diseases typically become apparent only after harvest and during fruit ripening. In most cases the producer is oblivious to these diseases since the symptoms are expressed after the fruit has left the farm. Heavy market losses occur every year due to these diseases. They can be minimized by better tree pruning, field sanitation, and proper application of fungicides.

Fruit flies are endemic to Pakistan and several different species attack mango fruit. Larva of adult fruit flies must not be found in the fruit in order to comply with phytosanitary requirements of many potential importing countries (i.e. Iran, China, Japan, U.S., etc.). Rigorous pre-harvest and postharvest pest management programs must be adopted by growers and exporters to avoid any fruit fly contamination on shipments intended for export. Iran and China require a postharvest hot water treatment, Japan requires a vapor heat treatment, and the U.S. requires an irradiation treatment of the fruit prior to export. Considerable postharvest research and

development work remains to be done in order for Pakistan to be able to supply these potentially lucrative export markets with consistent supplies of high quality mangoes. The use of sea freight will be necessary for large volume mango exports from Pakistan. Use of this mode of transport will allow Pakistani mangoes to be more competitive in long distance export market destinations. It is not clear how much of a detrimental effect, if any, the various insect disinfestations treatments will have on the mango fruit arrival quality.

In addition to fruit flies, other serious insect pests of mangoes are beetles, borers, thrips, midges, scale, mango pulp weevil, and aphids. Pheromone traps have been successfully used to trap the male fruit flies and various crop protectants are available to control the other insect pests.

Most mango growers in Pakistan do not use, or are not aware of, the optimal pest management practices for combating specific insects and diseases. There is a particular lack of information dissemination to the small farmers. Also, the provincial government agriculture extension agents are often under-trained in the latest technologies and materials to use to protect against certain pests.

The U.S. is a potential future market opportunity for fresh mango exports from Pakistan. However, all fruit must be free of insects (i.e. fruit flies, mango pulp weevil, etc.) in order to comply with the phyto-sanitary requirements of the U.S. Animal and Plant Health Inspection Service-Plant Protection and Quarantine Division (APHIS-PPQ). This will require a rigorous integrated pest management program in the orchards, coupled with field monitoring using pheromone traps and baits, random checking of the fruit at harvest, prevention of insects entering the packinghouse and transport vehicle to/from the PARAS irradiation facility, and physical exclusion of insects from entering the irradiation facility.

Recommendations

More on-farm applied research is needed to establish the proper prevention and control methods against the major mango insects and diseases. Improved integrated pest management strategies should be developed for minimizing pest damage. The FIRMS Project should develop and disseminate to growers well-illustrated technical guides describing specific pest management programs for all the common insects and diseases of mangoes in Pakistan. In addition, the Firms Project should help to establish private sector pest management service providers, which will offer crop protectant spraying services on a fee basis to growers that do not have the equipment or resources to spray their own trees. The initial establishment of these service .provider firms may be accelerated by matching grants from the USAID-funded Community Rehabilitation Infrastructure Support Program (CRISP) and/or the Competitiveness Support Fund (CSF) for the purchase of spray equipment and required accessories.

The Firms Project should provide training and technical assistance to growers in proper insect control and fruit fly avoidance practices in the field, as well in the packinghouse area after harvest. Irradiation treatment of mango fruit is an APHIS-acceptable insect

disinfestation protocol. However, the PARAS irradiation facility outside of Lahore has not yet been approved by APHIS. Numerous actions will be required in order to obtain APHIS certification for fresh mango exports to the U.S. These actions will require considerable time and money to complete. It is unrealistic to think the PARAS irradiation facility will be approved for mango exports to the U.S. prior to the 2010 harvest season. The existing obstacles are just too challenging to overcome in a short time period. These obstacles include certification of the irradiation facility by a team of APHIS inspectors, registration and approval of designated farms for export to the U.S., a Pakistani grower organization willing to be the liaison with APHIS in implementing the phyto-sanitary protocols with growers and exporters, petition of export interest to NEPHIS by Pakistani growers/exporters, communication by NEPHIS to APHIS on the intent to export mangoes to the U.S., payment by the Pakistani government, private sector, and/or donor agencies for the expenses involved in bringing a team of APHIS employees to certify the irradiation facility and mango production/packinghouse operations, and payment of the daily fees and per diem of APHIS inspectors to be present in Pakistan during use of the PARAS facility for irradiation of mangoes exported to the U.S. Once these actions are fulfilled, an additional period of several months will be required for APHIS to file the intent to import Pakistani mangoes in the U.S. Federal Register, followed by public comment, APHIS review, and final decision making. Although the list of actions needed to obtain APHIS certification and approval is long, it is in the interest of the Pakistani mango sector to open as many export market outlets as possible, including the U.S.

In anticipation of the eventual APHIS certification of the irradiation facility, the FIRMS Project should determine the arrival quality of trial shipments of irradiated mangoes in the upcoming harvest season. The trial shipments of irradiated fruit should be done by air and by marine container. Although it will not be possible to send non-certified mangoes to the U.S., it will be equally valid to send the mangoes to the U.K./E.U., since the approximate 18-20 day transport time from Karachi to England, Belgium, or the Netherlands is nearly identical to the transport time from Karachi to the metropolitan New York/ New Jersey area (via Maersk Lines). It is imperative to establish arrival quality success of irradiated mango fruit using small test shipments before investing heavily in the irradiation facility. There is no substitute for actual shipping trials in determining the likelihood of arrival success. The use of static holding chambers for simulated transport is not a thorough verification procedure. In the early 1970's, considerable research was done on the shelf life of irradiated fresh produce using static holding chambers. The early optimistic results from the static chambers turned into disappointment upon actual transport of the irradiated commodities. The physical movement and vibration of the product during transport and distribution had a negative synergistic impact on the arrival quality. Therefore, the Firms Project should assist in the trial shipment by air and sea of irradiated mangoes.

2.7 Harvesting Method

The vast majority (> 95 %) of mangoes grown in Pakistan are harvested by contractors, not by farmers. The farmer who sells his fruit to a contractor is mostly interested in obtaining high yields, because of the low price paid by the contractor. Contractors, usually on behalf of commission agents, provide cash flow to farmers by buying the crop soon after fruit set and advancing the grower a portion of the final return price. Contractors then take on the overall management of the crop. However, they are not motivated to manage the trees for fruit quality, because they are paid according to harvest volume and not fruit quality. The contractors often harvest fruit by hitting them with sticks and letting them fall to the ground. Improving the harvesting practices of the contractors is an obvious area to target in order to ensure better quality fruit. There is no incentive to produce high quality fruit for the domestic wholesale market. However, some retail stores are willing to pay higher prices for better quality fruit.

Improper harvesting methods can result in significant losses in mango fruit market quality. Mangoes are very delicate fruit and must be removed from the tree gently and treated like eggs. Extreme care must be taken to avoid sap (latex) burn, bruising, or mechanical damage at harvest. However, the workers arranged by the contractor to harvest the fruit often engage in rough harvesting practices that impart significant damage to the fruit, reducing the postharvest life and lowering market quality. Sap exudation from the cut stem is a serious problem if the fruit is not properly harvested and de-sapped after harvest. Any sap exudation from the cut stem that comes into contact with the peel will result in peel deterioration. Sap burn can be prevented by educating and training the harvesters on the proper way to pick the fruit, cut the stem, and de-sap the fruit. Placement of the fruit following stem removal must be in a way that avoids sap exuding onto the peel. Fruit should be placed stem-end down in perforated cell pack trays or metal drying racks to allow for the sap to exude from the cut stem without touching the fruit surface. De-sapping in a dilute lime solution (1.0 % calcium hydroxide) is also an effective way to avoid latex burn.

Recommendations

Training sessions should be offered by the Firms Project to farm managers, contractors, pickers, packinghouse workers, and provincial government extension agents on proper harvesting practices, stem removal, and de-sapping procedures. The Firms Project mango specialist should develop and conduct the training sessions.

2.8 Harvest Maturity

Proper harvest maturity is important to obtain good eating quality of the fruit and maximum market life. A current constraint negatively impacting the quality of Pakistani mangoes is the high amount of variability in individual fruit maturity during harvest. For example, contractors who purchase a grower's mango crop typically harvest all the fruit from the tree at once. This results in a wide range in fruit maturity, from over-ripe to immature. Such wide variation in fruit maturity is difficult to grade and classify into a

uniform packed product. This variability can be avoided by educating the pickers on the proper harvest maturity stage for each fruit coupled with multiple harvests per tree. Simple field instruments and internal pulp color charts exist that are capable of objectively measuring various quality and maturity parameters.

Recommendations

Technical assistance and training sessions should be offered by the Firms Project to growers, harvesters, and provincial government extension agents on proper harvest maturity indices for the different mango cultivars. Utilization of simple field instruments and color charts capable of objectively measuring fruit quality and maturity parameters should be demonstrated. Use of these color charts by the harvesters will help to reduce fruit immaturity and over-maturity and significantly improve product quality. Horticulture researchers at the University of Agriculture Faisalabad, in cooperation with the ASLP Project, have developed harvest maturity color charts for the principal mango cultivars. These color charts should be used as one of the indices for determining the appropriate harvest maturity stage of mango fruit, depending on the destination market. Growers providing fruit to the processors should also be trained in proper harvest maturity standards, appropriate harvesting methods, and the use of proper harvest containers. The maturity and quality of the fresh fruit is an important factor influencing the final processed product quality.

2.9 Postharvest Care Constraints

Constraints in the postharvest care of mangoes may be the weakest link in the supply chain, in terms of being able to supply the market with high quality fruit. Trade sources estimate between 25-30 % of the total mango harvest volume suffers postharvest fruit loss. Postharvest care constraints need immediate attention in order to improve the consistency and quality of Pakistani mangoes. Mango fruit have a high respiration rate and need to be cooled as soon as possible after harvest to their optimal holding temperature of 12-13° C in order to maximize market life. However, there is almost a complete lack of cooling and cold storage infrastructure on mango farms and the rate of fruit deterioration is rapid at high ambient temperatures.

Pakistani growers and exporters generally do not properly de-sap, grade, pack, and cool mango fruit. Rapid fruit softening and deterioration occurs under warm storage and transport temperatures. The absence of cooling mango fruit, which is typically harvested at high pulp temperatures in excess of 40° C, also results in an acceleration of anthracnose and stem-end rot. In addition, the lack of postharvest humidity control during storage and distribution to market results in significant fruit shriveling and a poor product appearance. Waxing of the fruit surface can minimize moisture loss from the fruit and preserve the desired appearance. However, a postharvest wax treatment for mangoes is typically not done in Pakistan.

Unfortunately, minimal effort is being made within the Pakistani mango sector to improve the postharvest care of the fruit, especially at the level of the small-scale producer. This negatively impacts product market quality and results in significant market losses. There is almost a total absence of modern and efficient packinghouse equipment and infrastructure for postharvest handling of mangoes in Pakistan. The lack of appropriate de-sapping, grading, packing, cooling, and cold chain maintenance during transport to market severely limits the capability of mango producers to provide consistent supplies of high quality fruit. In addition, domestic marketed fruit is typically ripened by using small pieces of calcium carbide placed inside the 10-kg wooden crate. The fruit surrounding the calcium carbide pieces is usually damaged and fruit ripening throughout the crate is often irregular. Furthermore, the use of this chemical is banned in many countries due to its alleged carcinogenicity. Ethylene gas has replaced calcium carbide as a ripening agent worldwide, but is limited in use in Pakistan.

Cost-effective and efficient on-farm packinghouse equipment and infrastructure is needed to be able to provide markets with high quality mangoes. The equipment should include de-sapping (1.0 % calcium hydroxide) and fruit wash tanks, along with metal or PVC racks for open-air fruit drying. This operation can be done in the field, provided there is access to potable water. The dried fruit should then be gently transferred into well-ventilated rigid plastic field crates and transported to a nearby packinghouse facility. Alternatively, the harvested fruit with the attached 6-8 cm pedicel can be put in the rigid plastic field container and transported to the packinghouse area for de-sapping. The packinghouse should include tables for manually sorting, grading, and packing of the fruit, a forced-air cooler for rapid removal of field heat, and cold storage for temporarily holding the fruit at 12-13° C after cooling. Additional equipment which is important includes an ethylene ripening chamber for fruit destined for the domestic market and a hot water treatment system for fruit intended for export. This hot water treatment system should be designed to maintain the water temperature at 52° C while the mango fruit are submerged for 3-5 minutes. It will be an effective method to reduce the incidence and severity of *Diplodia* stem-end rot and anthracnose fruit rot. However, this treatment is not effective in killing fruit fly larvae. The hot water phytosanitary treatment for insect disinfestations requires a different design and time-temperature protocol, depending on the export market destination (i.e. 48° C for 60 minutes for China).

On-farm cooling and cold storage will allow producers more control of their market. The contractors and commission agents involved in fruit procurement from the producer can use the lack of cold storage infrastructure to their advantage by offering low purchase prices for the mangoes. Potentially higher prices can be obtained if marketing gluts can be avoided by temporary product storage, followed by improved packing and more efficient distribution to market. A schematic diagram illustrating the individual steps in preparing mango fruit for market is included in the Appendix. The design of an on-farm packinghouse for mangoes should include the necessary equipment and supplies for each of the individual postharvest care steps. Sufficient cooling and cold storage capacity should be available to handle peak harvest volume fruit loads. The design of a

modular cooling/storage area with a daily capacity of 11 metric tons of fruit is included in the Appendix.

Recommendations

The recommended sequence of mango postharvest care practices illustrated in the Appendix should be carefully followed. Improvements in each step and any reduction in the amount of postharvest fruit loss will have a significant positive impact on the economic value of the crop. The Firms Project should help facilitate the establishment of low-cost on-farm packinghouses, cooling, and temporary cold storage facilities. They should utilize a significant amount of manual labor in order to have the desired economic impact to the local villages and communities. An appropriate model to emulate would be the kinnow industry, which has >150 packinghouses for this citrus fruit. The driving force for the kinnow postharvest infrastructure improvement during the last decade has been the increasing export market demand. Further analyses of the design, logistics, equipment needs, operation, and economics of the proposed postharvest infrastructure improvements for the mango sector should be part of the initial Firms Project work activities. Each packinghouse should have the basic equipment for product receiving, sorting, cleaning, grading, packing, cooling, and storage.

It is important to design the mango packinghouse facility to have a smooth and efficient flow of fruit. The unloading area should be shaded and under a roof and roller conveyors should be used to facilitate product flow. A series of de-sapping racks and/or wash water tanks should be placed near the unloading area. Utilization of de-sapping racks to stop the latex flow out of the stem will require more time to complete compared to submergence in dilute calcium hydroxide followed by cleaning in potable water. However, most mango producers feel the appearance of the peel is better using manual de-sapping racks versus calcium hydroxide and potable water wash tank submergence. Added benefits of using de-sapping racks include less cost and more use of manual labor, particularly women. Following de-sapping, the mango fruit is typically cleaned by rubbing the surface with a damp cloth. Another cloth may be used to apply a thin film of wax to the fruit surface, which will minimize fruit shriveling and improve the luster of the peel. Those producers that choose to use the calcium hydroxide/water submergence method for de-sapping must use sanitary (potable) wash water in order to comply with GlobalGAP requirements.

The packing line should be designed so there is linear movement of fruit from the cleaning area to the sorting/grading area to the packing/weighing area. An insulated marine container or a custom-made modular unit should be located inside the packinghouse and equipped with sufficient refrigeration capacity to serve as a cooling and temporary cold storage facility. This will circumvent the need to construct a high cost cooling and cold storage building, which would likely not be affordable by many producers. The cooling and refrigeration chamber infrastructure can also be used for packing, cooling, and temporary storage of other fresh produce items after the mango season ends. This will increase the use of the facility and improve the return on

investment cost. The capacity of the on-farm cooling and refrigerated cold storage infrastructure should be consistent with the packing and cooling needs of a medium-sized production operation, which is capable of preparing and cooling about 11 tons of mangoes per day. The packed and cooled fruit can be palletized and easily transferred to refrigerated trucks or a marine container for in-land transport to Karachi and distribution to various export markets.

An alternative to on-farm packinghouses equipped with cooling/cold storage infrastructure would be a larger facility designed to serve the needs of multiple growers. The Government of Punjab/PAMCO is planning to construct a modern mango packinghouse and cooling facility in the Multan area next year. The design and capacity of the facility is under review. A similar facility in Sindh would also be a significant addition to the mango sector and would be the first such facility in Sindh province. The Firms Project should cooperate with the GOP/PAMCO in the design of this facility and offer guidance in the necessary equipment required to make this a multi-crop postharvest care facility. This packinghouse will likely serve as a collection point for wholesalers and exporters. It should be located at appropriate sites which allow for maximal use by smallholders farmers. The ownership and operation of the larger packinghouse facilities should be placed within the private sector. This will give a greater likelihood of long-term sustainability of the facilities. Funds for maintenance and operational costs of the facilities should be generated by user fees. However, there is currently no example within the horticulture sector in Pakistan that has a functioning and sustainable central packinghouse facility serving the needs of multiple growers. Therefore, establishment of this type of facility will require careful attention to detail pertaining to coordination of product arrival and processing from multiple growers.

The volume of fruit capable of being handled at this government-constructed multi-crop packinghouse would be significantly greater than the individual on-farm units. The larger facility would require a concrete floor, insulated building, and much larger refrigeration capacity for cooling and temporary cold storage. In addition, this facility should have a temperature-controlled hot water treatment system capable of treating the fruit at 52° C for 3-5 minutes (depending on cultivar) in order to disinfest the skin surface of fungal disease. The hot water system should be versatile enough to also treat mango fruit at 48° C, which is a phytosanitary insect disinfestations requirement of Iran and China. An ethylene ripening chamber should also be a component of the packinghouse to facilitate uniform fruit ripening for the domestic market, circumventing the need to use calcium carbide. Certain high-value export markets also prefer ready-to eat mango fruit.

The packinghouse and cooling facilities should be designed for multi-crop use, in order to maximize the return on investment cost. In most cases, the equipment used for cleaning, grading, packing, and cooling of mangoes can also be used for other fruit and vegetable crops before/after the mango season.

2.10 Fruit Grading

Lack of fruit uniformity within a package is a serious constraint to marketing mango fruit, particularly for export. It is very important to have as much uniformity of fruit size, shape, and color within the package as possible. Some countries have national grade standards for mangoes that growers must conform to. Such grade standards do not exist in Pakistan, and therefore a wide variation in fruit quality is common in the domestic market. This does not facilitate orderly marketing of the products and buyers are reluctant to pay premium prices because of this lack of product consistency. In some cases, fruit which have fallen tree onto the ground are put in the bottom layers of the wooden crate and the better appearing fruit are packed on the top layers. Bruised and partially decayed fruit are often mixed in the same container. An informal grading system is used in classifying mango fruit for the domestic market. There are 4 grades: A, B, C, and D, with grade A being the highest quality.

Recommendations

Industry-developed grade standards should be developed to improve the orderly marketing of mangoes (and other fruit) in Pakistan. Representatives from the private and public sector should begin discussions on how to implement such a grading system. The grade standards should be based on internationally accepted norms, such as Codex Alimentarius, E.U. standards, or U.S.D.A. standards. The result of these grade standards will be stronger confidence in the domestic marketing system, higher prices for better quality product, and discipline imposed within the industry in marketing mangoes. The FIRMS Project should facilitate the development of these industry-established grade standards. A series of training courses should be offered to growers and fruit packers on proper grading and fruit classification procedures.

2.11 Packaging

The packaging materials used for marketing the majority of Pakistani mangoes are not conducive to protecting the fruit quality. In addition, most packages are inferior in appearance, construction, and design for the export market. Unfinished 10-kg wooden crates are widely used for domestic marketing of mangoes in addition to some exports to the U.A.E. The outer appearance of the crate is not attractive and does not enhance the value of the fruit inside. Furthermore, the rough inner surface of the wooden crate can result in significant abrasion of the delicate skin of the mango. Overstuffing of mangoes inside the crate also results in substantial compression injury of the fruit, followed by pulp breakdown as the fruit ripens. Newspaper and straw are commonly used to line the inside of the wooden crate, but these materials are not appropriate for export marketing fruit to supermarkets or high-end stores. The additional weight of the wooden crates versus corrugated cartons results in higher transport costs. Food safety regulations and packaging restrictions against the use of wood containers in many export markets preclude the use of this type of packaging in the international market. Strong, well-ventilated, attractive corrugated cartons are the norm in packaging mangoes for export. It is imperative that Pakistani exporters pack mangoes in high quality, strong, and attractive corrugated cartons that will withstand the rigors of transportation and distribution. In the case of the E.U. retail market, this typically

consists of a 2-ply side-ventilated, open-top, 4-kg corrugated carton made from virgin paper stock. Illustrations of this carton are included in the Appendix and it is available from a carton manufacturer in Dubai. Domestic carton manufacturers currently only fabricate weaker, single-ply, closed top or telescopic cartons, made from recycled paper stock. Roshan Enterprises, the major corrugated carton manufacturer for the produce industry in Pakistan, has the capability to make stronger 2-ply cartons from virgin paper stock, but due to lack of demand has not invested in making this type of carton. The physical specifications of the export carton preferred by the leading U.K./E.U. importers is typically provided by them to the supplier in advance of the harvest season. The 4-kg cartons currently used by Metro for their shipments to Europe would be acceptable by nearly all E.U. importers procuring fruit for the mainstream supermarket retailers.

Recommendations

The mango industry in Pakistan should shift from the use of wooden crates to strong, properly ventilated corrugated cartons. Attractive, high impact graphic cartons designed to get the attention of the buyer are needed for high-end niche market segments. The FIRMS Project should provide technical assistance to carton manufacturers to help improve their capacity to produce stronger 2-ply cartons and link them to existing and potentially new mango exporters.

2.12 Transportation

Transport of the mango fruit to market is a significant constraint to the sector and typically results in significant fruit bruising and quality loss. Mangoes sold in the domestic market are generally transported in non-refrigerated overloaded Bedford trucks. The transport time from the farm to the final domestic market destination ranges from 1 to 3 days. The combination of poor quality packaging materials, overloading of the transit vehicle, and lack of refrigeration after harvest and during transport results in significant product quality loss during distribution to market. The lack of a cold chain during domestic transport of mangoes is a major constraint to proving markets with consistent supplies of high quality fruit. Deterioration and loss of fruit quality is very high at ambient temperatures.

Depending on the export market destination, mangoes are either transported by marine container or by air. In addition, in-land freight is required to transport the fruit from the production area and/or packinghouse to the Karachi seaport, or to the Karachi airport. The majority of the exports from Pakistan are sent via Karachi. The mode of transport varies according to the final market destination shown below.

Table 1: Transport modes and share of mango export trade from Pakistan			
Destination	Air	Sea	
		Refrigerated	Non- Refrigerated

Table 1: Transport modes and share of mango export trade from Pakistan

Destination	Air	Sea	
Middle East	40 %	30 %	30 %
Eastern Asia	100 %	0%	0%
U.K./E.U.	100 %	0%	0%
Others	75%	10%	15%

Source: PHDEB

Pakistan International Airlines (PIA) and Emirates are the two main airlines transporting mangoes abroad. Air freight rates have decreased with increasing capacity at the country's airports. The airfreight cost of mangoes to the U.K. is priced between \$1.05-\$1.30/kg, depending on volume and carrier.

Sea freight cost of exporting mangoes from Karachi to the U.K. and Northern Europe is about one-fifth the cost of sea freight (~\$0.25/kg). However, arrival time ranges from 18-24 days and most mango cultivars will not withstand this lengthy duration. Nevertheless, new controlled atmosphere (CA) transport technology is available from Maersk and several other shipping lines which have been shown to be successful in transporting fresh mangoes for voyages requiring up to 3 weeks. A significant amount of mangoes from South American suppliers is exported in CA marine containers to European market destinations. Preliminary shipping trials done by Metro in cooperation with postharvest researchers at Faisalabad Agriculture University (FAU) indicated the arrival quality of Sindri and White Chaunsa cultivars at destination was acceptable. Further trials on the use of CA marine transport for mangoes are planned, including with other cultivars. Preliminary results using the standard Chaunsa cultivar were not favorable. Nevertheless, CA marine transport of fresh mangoes offer significant hope for opening new long distance export markets, including North America. The sailing time from Karachi to the New York metropolitan area is 21 days, which is similar to the time required to reach northern E.U. ports.

Recommendations

The Firms Project should continue supporting the development of CA marine transport of fresh mangoes. This should involve close cooperation with Metro and UAF in optimizing the oxygen and carbon dioxide gas levels for successful sea freight arrival of different mango cultivars. Research studies are also needed to test the arrival quality and market life of irradiated mangoes shipped by CA marine container to the U.S. If the results are positive, it will significantly expand the potential export volume of Pakistani mangoes to the U.S. market. Initial CA shipment trials from India to the U.S. this year were reported to be successful.

The cost of transport is the single-most expensive item in mango exports to distant markets. The use of CA marine containers would reduce transport cost from 160Rs/kg from Lahore to New York (via PIA) to \$0.35 Rs/kg via Maersk Lines. The lowered

transport cost would allow U.S. retailers to market mango fruit at a significantly lower price compared to expensive air-freighted mangoes. A lower retail price in U.S. supermarkets would generate considerably greater sales volume. Pakistani mangoes have an excellent flavor and texture and could be marketed as premium quality fruit.

2.13 Agro-Processing

Although the market price for mango fruit sold to agro-processors is typically much lower than that sold in the fresh market, it is important for the growers to have as many market options as possible. In addition, agro-processors often accept variable quality fruit from producers that is not appropriate for the fresh market. However, the quality of the fresh fruit used for processing should be sufficiently high so the quality of the agro-processed product is not compromised. Processors should not be viewed as a dumping ground for low quality fruit. It is desirable to have the agro-processing facilities in the areas near the mango production zones. This will help minimize the adverse quality changes which can occur in the raw fruit due to extended time periods at high ambient temperature between harvest and the beginning of fruit processing.

The existing agro-processed mango products with significant domestic and international market demand include pulp, nectar, squashes, juice drinks, jams, pickles, and chutney. There is no significant commercial production of dried mango slices, frozen mango products (block frozen, IQF, freeze-dried), or fruit rolls/leathers. In addition, there is no processing of mango peel and kernel-based products into non-edible commercial products. This would include pectin derived from dried peel tissue, topical creams and lotions made from mango kernel oil, and animal feed supplement made from high protein and high fiber kernels.

Recommendations

Agro-processed and value-added mango products should continue to be developed and improved. Significant domestic and export market opportunities exist for a number of new agro-processed mango products, in addition to the existing pulp, jam, pickle, and chutney products currently being produced. The new value-added mango products which should be developed during the course of the FIRMS Project include dried mango slices, mango fruit rolls/leathers, individual quick frozen (IQF) mangoes, and commercial products from mango kernel oil (i.e. cocoa butter substitutes, skin creams, lotions, etc.). Other possible agro-processed mango products include freeze-dried mangoes, spray-dried powder, pectin, and animal feed supplements. In order to help develop these potential new products and strengthen the existing agro-processed mango products, one or more food technologists with significant experience should be contracted by the Firms Project. This person(s) should be responsible for working directly with the private sector in assisting to improve the portfolio diversity and quality of Pakistani processed mango products for both the domestic and export market. Establishment of small-scale agro-processing operations in rural villages near the fruit production areas should be promoted. This will help strengthen the local economy and provide jobs to the local workforce. Human resource capacity building in agro-processing plant management and technical skills in equipment operation should be

integral parts of Firms Project training and technical assistance programs to support the agro-processing industry. An immediate goal of the Firms Project should be to develop a commercial dried mango export industry. Surprisingly, there is no domestic supply or exports of dried mangoes from Pakistan. This value-added product has an excellent domestic and export market potential. The high sugar Chaunsa (~24° Brix) cultivar would be ideal for producing dried mango slices. Furthermore, the processing of dried mango slices does not require significant capital investments and would be an ideal product for women-based small-scale enterprises. Women would also be direct beneficiaries of a strong dried mango industry, since it would create significant employment opportunities for rural women. Development of other agro-processed mango products would also create substantial employment opportunities for women.

2.14 Marketing

Most mango producers sell their entire production to a contractor well in advance of harvest. The contractor then arranges for workers to pick the fruit. The contractor typically consolidates the fruit purchased from multiple growers, acting on behalf of a commission agent who sells the fruit in the wholesale market. This marketing system reduces the potential return received by the grower for the mangoes. Direct marketing of mangoes to wholesale or retail buyers in Pakistan is limited. More direct marketing by the producer to the buyer would eliminate one or more intermediaries and allow for a higher return price to the producer.

Many mango producers in Pakistan are not closely linked with buyers or agro-processors. The grower's product is generally marketed through middlemen that accumulate, pack, and transfer the product to the market. The price offered to growers by the middlemen is considerably lower than what they might get if they could more directly market their production.

Another important market constraint is the limited contact between international importers and Pakistani suppliers. This is particularly evident for the export market. Significant opportunities exist to develop the high-value retail market trade for Pakistani mangoes in the E.U., North America, and Asian market destinations. However, significant improvements will be necessary over the current variable product quality in order to penetrate these markets.

The lack of federal grade standards for individual fresh produce items hinders the efficient domestic marketing of mangoes. The international Codex Alimentarius standards are suggested as guidelines to follow, although without proper enforcement there would likely be a lack of adoption by the growers and marketers.

Lack of a timely and robust domestic market news service has been a constraint to efficient marketing of mangoes. Dissemination of market price information to growers has historically been a limitation. However, a recent agriculture marketing information service has been initiated by the Directorate of Agriculture (Economics & Marketing), Government of Punjab. Daily market prices are posted on the website: www.amis.pk for

multiple mango cultivars in numerous wholesale markets throughout the province. This is an excellent market price information service, easily accessible by all producers with access to the Internet.

Recommendations

The mango growers are typically at the mercy of the commission agents/contractors when marketing their fruit. Over 95 % of the mangoes produced in the country are sold to commission agents prior to fruit harvest. The commission agent hires a contractor to harvest the fruit. The Firms Project should help to facilitate direct marketing of the mango fruit by the grower to the final domestic market buyer. In the case of exports, expansion of existing markets and concomitant development of new export markets are essential for growth of the Pakistani mango sector. Pakistani mango exporters need to strengthen their position in the Middle East countries and establish a stronger market presence in the E.U. The U.K. and Germany are the largest importers of mangoes in the E.U. and Pakistani exporters need to expand their presence in these large markets.

Similarly, Pakistan needs to establish strong market presence in France, Italy, Belgium, and the Scandinavian countries. Large supermarket chain stores dominate the sales volume of mangoes in the E.U. Each of these supermarket retailers use a specialized import company to source and procure their fruit. A list of the leading mango importers representing the mainstream supermarkets in the U.K. and E.U. is shown in Appendix 2. Efforts should also be concentrated on establishing new export markets for fresh mangoes in retail supermarket channels in North America. In addition, export market development of agro-processed mango products should be targeted, including new value-added products like dried mango slices, fruit rolls/leathers, and IQF mangoes. In order to facilitate the export of Pakistani mangoes to the E.U. retail supermarket trade, the Firms Project should invite several of the leading importers to Multan to meet the growers and become familiar with the supply chain. Preliminary discussions with the importers representing the supermarket giants of Tesco, Marks & Spencer, and Waitrose have been positive and the importers expressed their willingness to participate in workshop linking them with producers. This workshop will provide the venue for the producers to understand more about the potential market opportunities in the high-value U.K./E.U. retail market trade. In turn, the importers will provide first-hand information to the potential suppliers on the product quality, packaging, and postharvest handling methods important for success in the E.U. market. A full-day workshop in Multan should be arranged, which will also include additional domestic and international mango experts covering the topics of better agricultural practices and postharvest care. Buyers/importers from Dubai and other regional markets have been identified and will also be invited to talk about opportunities in their respective markets. This event should be conducted in the near future (i.e. January).

In order to establish a significant presence in E.U. retail markets, it will be necessary that a number of Pakistani mango producers and exporters meet GlobalGAP certification requirements. All of the major retail supermarket chains in the E.U. require GlobalGAP certification from their suppliers. In the future, smaller retailers and some wholesale market buyers will also implement GlobalGAP-certification requirements from their suppliers. Existing and potential mango exporters in Pakistan should receive

training by the Firms Project on the requirements of GlobalGAP and how to obtain certification.

Organically-grown fruit and Fairtrade-labeled mangoes should be added to the overall product portfolio available for marketing from Pakistan. They typically return around 30 % more in value to the supplier, compared to conventionally grown mangoes and world demand for organically-grown fruit continues to significantly outpace conventionally-grown fruit. In order to take advantage of this market growth opportunity, it is recommended that a concerted effort be given to establishment of organically-certified farms which will be able to comply with the international standards and statutes required for official certification. Although conventionally-grown mango fruit will continue to dominate the mango trade, it is important to have at least a part of the Pakistani mango sector capable of meeting the increasing organic fruit market worldwide.

Attendance by potential mango exporters at the premier international horticulture marketing trade show is important in order to expose private sector exporters to international requirements for packaging, product quality, and marketing. Fruit Logistica in Berlin (February, 2010) is recommended, as it is the largest international fresh produce trade show in the world. It is the best trade show for Pakistani exporters to network with E.U. importers and buyers and establish potential business deals. It will be imperative for the Pakistani mango industry to perfect successful marine transport of fresh fruit to international market destinations. This is necessary to keep the arrival cost to a minimum. The three requirements which must be met in order to establish a presence in the international market include being able to supply the importer with 1) consistent supplies of 2) high quality fruit at 3) competitive prices. The third requirement of competitive price typically means a retail supermarket price of \leq €0.99 per kg in continental European retail stores, \leq £0.99 per kg in U.K. retail stores, and \leq \$0.99 per lb in U.S. and Canadian retail stores. In European and North American markets, the consuming public typically prefers a large-sized mango fruit weighing between 400-450 gm. Therefore, on a per fruit basis the price „break-point“ which results in significant consumer resistance and reduced sales volume at the retail level is anything \geq €1.00, £1.00, and \$1.00 in the respective international destinations. The only way to be able to allow Pakistani mangoes to be sold at competitive prices compared to other supplying nations, while still allowing for the growers, exporters, importers, and retail stores to all make a profit, is to transport the fruit via lower cost marine transport. The cost of air freight is roughly 4-5 times more than sea freight to European and North American destinations.

An economic analyses should be made of the total costs of production, harvesting, packing, cooling, transport (air and sea), and marketing to the different potential export market destinations. Where required, this economic analysis should include the cost of compliance with the required phytosanitary protocol of the importing country. In order to have a sustainable mango export operation, it will be essential for total revenues to exceed costs. This has not been sufficiently analyzed for the different potential export market destinations. With this information, the FIRMS Project can better prioritize resources to target specific potential market destinations. For example, the high cost of

complying with U.S. phytosanitary requirements will likely be a barrier to penetration of this market unless lower cost sea freight can be developed as a reliable transport option.

2.15 Industry Organization

A serious limitation in the Pakistani mango sector is the lack of organization and cohesiveness among the sector. There are few mango producer associations, and the existing ones do not have sufficient size to represent the mango sector on government policy matters, market development, research-related activities, or receiving of training and technical assistance. A strong mango industry association is also needed in order to influence the type of applied research the growers would like to have addressed.

The majority of the mango production in Pakistan comes from small-scale farmers with several hectares or less. Single producers cannot supply large buyers with sufficient quantities to make them attractive suppliers. The lack of economy-of-scale mango operations and inadequate coordination among smallholders makes it difficult to reach the volume of supply necessary to gain access to global markets. Helping mango producers to organize so they can be capable of marketing their fruit together can create a beneficial relationship for buyers and sellers. Likewise, while small farmers may have mangoes to sell, it is nearly impossible for large buyers to procure from them since they do not have the manpower to deal with so many small farmers. By organizing and providing buyers with a single point of contact, small producers can gain access to larger retail channel marketing outlets.

Consolidating the production from multiple smallholder producers to meet minimum buyer requirements will be desirable. It is also more economical for producers when supplies can be purchased in larger quantities for an association of multiple growers. From a sector developmental perspective, providing information and training to group of producers is likewise more efficient and cost-effective than on an individual basis. Other possible areas of Firms Project assistance could include access to financing and obtaining Global GAP certification and HACCP compliance. Global GAP certification of the production and packinghouse operations is a requirement of all mainstream retail supermarkets in Europe, while a HACCP program must be implemented by all agro-processors.

Recommendations

Where possible, the Firms Project should strengthen existing mango producer organizations and help develop new, self-sustaining producer organizations or clusters. The Project should encourage the establishment of these producers associations and clusters to increase the communication within the mango sector, obtain technical assistance and training on all aspects of production and postharvest care, work toward establishing product grade standards, improve market intelligence, and strengthen the sector's position in government policy matters and access to financing.

2.16 Applied Research

Mango producers in Pakistan need the help of the provincial government agriculture departments and research institutions to overcome the numerous production and postharvest constraints that compromise the yield and quality of the fruit. There is insufficient applied research being conducted at the provincial and national level to support the mango sector. Some problems are extremely threatening to the mango sector (i.e. mango SDS) and need a significant infusion of resources to diminish existing threats. The Mango Research Station in Shujaabad does not have adequate funding or staff capable to address the multitude of industry-threatening constraints. Another concern is the lack of coordination between national agriculture university research programs and those of the provincial governments.

The agro-processing sector also needs support in maintaining the quality of various finished products. For example, color retention of mango drinks is a serious concern. Mango juice and drinks are important commercial agro-processed products in Pakistan. Non-enzymatic browning of these products can occur after processing, resulting in a gradual darkening of the juice or drink. This is highly undesirable from a quality standpoint. The export market for Pakistani mango drink products is at risk if the color of the bottled product darkens with time.

Recommendations

The Firms Project should encourage a closer working relationship between provincial government agriculture research and extension efforts focused on the mango sector, MINFAL, and private sector mango industry stakeholders. The private sector should have input into research priorities and programs as part of official advisory committees. Mangoes crops should be prioritized in government research programs in order to increase the sector's competitiveness and economic growth potential.

The Firms Project should support research and/or technical assistance on measures to alleviate quality changes in processed products, such as mango juices, nectars, and drinks. Post-processing darkening is a serious concern among many processors, which results in an undesirable product quality change.

2.17 Grower and Provincial Government Extension Agent Knowledge

Development of the Pakistani mango sector is constrained by lack of information and knowledge regarding the optimal production practices and postharvest care techniques for mangoes. There is inadequate grower and provincial government extension agent knowledge in order to overcome existing production, pest management, postharvest care, and marketing constraints. Extension agents with knowledge of the latest information and technologies coupled with significant field experience are simply not available to the mango growers. Most extension agents have a general understanding of agriculture, but have not had the training to be in-depth specialists. This is a constraint because mango-related issues are often unique and require a specialist for diagnosis and problem solving.

The linkage between applied research and agriculture extension is critical to strengthening the mango sector. Currently, there is no formal link between the agriculture university research institutes and the provincial government extension programs. Although some extension-related information on mango production is available at the provincial level, there is limited dissemination and a general lack of follow-up with the farmers. The result is less than optimal yields and highly variable fruit quality. This is not conducive to establishing a competitive mango operation. In addition, human resource skills training is needed in management and business related aspects of the operation.

Recommendations

The Firms Project should focus on working with larger growers (≥ 50 acres) that have the knowledge base and capital to invest and implement project recommendations. There are approximately 300 growers with > 50 acres of mangoes in the Multan area. The Firms Project has to show results within a 4-year period and it will be essential to focus energies on those producers that are/will be Global GAP certified. Training activities should be patterned after a modified farmer field school model. Several farms should be identified as willing participants to house the training activities, which will be conducted on a regular basis to production managers of medium-sized mango farms. Small growers should also be invited to participate in all training activities. In order to establish credibility, Firms should establish an information dissemination center in Multan, staffed by a knowledgeable mango technical specialist who can receive questions and provide answers to mango growers. This will require a full-time hire. This information center will be linked to in-country and international technical experts/resources. Implementation of the Firms Project work activities will require a full-time mango production specialist in the Multan area. This person should be well-experienced and highly competent in all areas of mango production and postharvest care.

The Firms Project should hire experienced and technically competent mango production specialists on an as-needed basis to supplement the training and technical assistance work of the full-time mango specialist. This core group should serve as the knowledge dissemination base for project activity implementation. They should develop their own training and technical assistance work plan, to be approved by Firms Project upper management, with input from all mango sector stakeholders. The Firms Project needs a mango sector information center in Multan, possibly located at the local agricultural college to access the knowledge base of the local staff and utilize their existing support services. This mutually beneficial relationship may also be important for future sustainability of the mango sector training and technical assistance activities after the Firms Project ends.

International and domestic resource persons who are specialists in mango production practices, harvesting, postharvest care, marketing, etc. will be called upon to provide the latest technical information and training to growers, provincial government extension agents, and Firms Project resource specialists on an annual basis in the form of a 2-day

workshop and field demonstration training seminar. This seminar should be held in both Punjab (i.e. Multan) and Sindh (i.e. Karachi) provinces. When necessary, additional experts will be called upon to provide supplemental targeted training and technical assistance to help overcome constraints of immediate importance.

Agriculture extension agent mango-related knowledge needs strengthening. A series of mango production practice and postharvest care workshops and training sessions should be held throughout the year for growers and provincial government agriculture extension agents. The full-time Firms Project mango specialist, supplemented with domestic and international specialist(s) should conduct multiple workshops in each of the Firms Project mango-growing districts covering all the technical aspects of production, harvesting, postharvest care, and marketing of mangoes. Field demonstrations and dissemination of technically detailed production/postharvest guides should be part of the training workshops. The pre-harvest production practices that are in need of immediate improvement include pest management (disease and insect control) and tree pruning. Pre-harvest disease pressure is directly correlated with postharvest fruit decay. The principal diseases that are responsible for mango fruit rot during marketing are stem end rot (*Diplodia*) and anthracnose. Proper pre-harvest disease management practices coupled with better tree pruning will minimize the fungal inoculum concentration on the mango fruit surface prior to harvest. A fruit with low levels of stem end rot and anthracnose spore contamination will be less likely to rot after harvest and during the marketing period.

Pre-harvest fruit fly and other insect control practices are also imperative in order to reduce the population of these pests on fruit intended for export. The eventual opening of the U.S. market to fresh Pakistani mangoes will require complete elimination of these insect pests, beginning in the field and continuing during postharvest handling. The other pre-harvest production practices in need of improvement that will directly impact the vigor of the tree and market quality of the fruit include tree nutrition and irrigation. Two serious disorders of mango fruit in Pakistan are malformation and jelly seed. Improved control of various *Fusarium* species will reduce the incidence of malformation, while supplemental application of calcium and boron to the trees will minimize the occurrence of jelly seed.

A significant component of the Firms Project should be information dissemination, technical assistance, and training of the mango producers and provincial government extension agents. This should include regular training workshops and on-farm demonstration activities on all aspects of mango production, (i.e. good agricultural practices, integrated pest management, tree pruning, irrigation, fertilization, etc.). A combination of a knowledgeable local mango production specialist(s) complemented by international mango experts should be used for information dissemination and capacity building of the growers and extension agents. The full-time Firms Project mango specialist should be very knowledgeable in all aspects of mango production and should regularly visit individual growers and assist in helping them improve their production practices. This person should be the direct liaison between the Firms Project and individual growers and will be networked to cooperating domestic and international

mango experts who can assist in answering questions or finding solutions to mango-related constraints. The training activities of the Firms Project mango specialist should be done on the farms of cooperating stakeholders who are serious partners in improving the Pakistani mango sector and are willing to open their farms for training and technical assistance to others. The physical location of the Firms Project mango specialist should be in the principal mango production district (i.e. Multan for Punjab Province).

The following Pakistan-specific technical guides are recommended to be written to increase the mango-related knowledge base of producers and provincial government extension agents. These technical guides should be written as soon as possible and will be valuable sources of information for dissemination to growers and agriculture extension personnel. The suggested topics to be included in the mango technical guides are listed below.

I. Production Practices

- a. Cultivar and Rootstock Selection
- b. Soil Preparation
- c. Plant Establishment
- d. Fertilization
- e. Irrigation
- f. Training
- g. Pruning
- h. Pollination
- i. Weed Control
- j. Insect Control
- k. Disease Control

II. Harvesting

- a. Crop Maturity Indices
- b. Harvest Methods
- c. Field Grading
- d. Field Containers

III. Cooling and Storage

- a. Infrastructure
- b. Temperature
- c. Relative Humidity
- d. Postharvest Diseases
- e. Postharvest Disorders

IV. Preparation for Export Marketing

- a. Cleaning
- b. Sorting
- c. Grading
- d. Packaging

A series of train-the-trainer workshops on all aspects of mango production, harvesting practices, postharvest care, and marketing should be provided to provincial government extension agents, in addition to local growers. These should be conducted using Pakistani specialists, industry personnel, and international mango experts.

Benchmarking study tours to leading mango producing countries can also be an effective method of information dissemination and human resource capacity building. These study tours should be arranged to observe the following: mango production practices, packinghouse operations, cooling and cold storage facilities, university and government mango research institutes, integrated pest management (IPM) research activities, wholesale and retail produce markets, and fruit crop equipment manufacturers (soil preparation implements, irrigation equipment, harvest aides, packinghouse equipment, packaging).

The model of using modified farmer field schools, comprised of groups of farm managers and individual farmers, is also an efficient way to disseminate extension information and this should be encouraged. Farmer participation in the training sessions is recommended and training should be done all aspects of production, harvesting, and postharvest care.

2.18 Financial

A universal constraint to the development of the mainstream retail supermarket export trade is the lack of investment by the growers in the necessary infrastructure which is required for successful arrival quality of the mango fruit. This includes an on-farm packinghouse equipped with the proper postharvest infrastructure to preserve the fruit quality. The lack of capital and/or unwillingness among the potential grower/exporter to spend significant amounts of money on the necessary postharvest care infrastructure is due to a combination of reasons. This includes the lack of market linkage between the potential grower/exporter and the supermarket retail importer, aversion to risk among growers, lack of capital required to make the necessary improvements, and unawareness of the postharvest care technology required at the farm level for export market success. Lack of financial resources and/or the aversion to risk among producers is a significant constraint for investment in the necessary on-farm cooling and cold storage equipment, hot water treatment system, and higher quality corrugated cartons.

Recommendations

In order to help jump-start the high value and high volume retail supermarket export trade, it is recommended for the Firms Project to identify several Global GAP-certified producers to develop as models for establishing success in the E.U. supermarket trade. Financial assistance will be an essential element in establishing these models and initiating trial shipments of mangoes in 2010 with willing E.U. importers. Considerable grower interest exists in initiating these infrastructure improvements and the penetration of Pakistani mangoes in the mainstream E.U. retail supermarkets. Several trial shipments of fruit from different Global GAP-certified producers to at least two different E.U. importers should be the target for the 2010 season. The trial shipments should be done by both sea (20-foot refrigerated CA container) and air. In addition, trial shipments of irradiated fruit should be done to the U.K./E.U. in order to ascertain the arrival quality

of the fruit. The cost of the on-farm postharvest infrastructure, higher quality 4-kg corrugated cartons, sea freight/airfreight transport cost, and the value of the fruit should be shared between the growers, Firms Project, and other possible stakeholders (i.e. Government of Punjab, importers, transport companies, etc.). Possible sources of financial assistance, for the postharvest infrastructure include the CRISP and CSF programs. CRISP is a recently initiated USAID-funded infrastructure development financial assistance program and CSF financial support program is a joint venture of the Ministry of Finance, Government of Pakistan, and USAID.

3. Market Opportunities for Commercial Mango Products

3.1 Fresh Market

3.1.1 Domestic

As the world's sixth most populous nation, with 176 million inhabitants, Pakistan has a large domestic market for fresh and processed mango products. The domestic market demand for fresh mangoes is increasing. This is primarily fueled by the high rate of population growth, which is estimated to be 1.95 % annually. This is the highest population growth rate among the world's 6 most populous nations.

The majority of Pakistani mangoes are marketed through the different wholesale markets located in the major cities. The fruit is procured on a daily basis in these wholesale markets by donkey cart vendors, shop owners, retailers, and exporters. The majority of the domestically marketed mangoes are sold by donkey cart vendors to individual consumers.

The recent entrance of three international supermarket chains into Pakistan within last 2 years will give mango producers additional domestic market opportunities. These three supermarket chains already have, or are planning to open multiple retail outlets in the largest cities of Pakistan. The wholesale club stores Makro and Metro each have multiple stores in the larger urban population centers. The world's second largest supermarket retailer, Carrefour, opened its first hypermarket (Hyperstar) in Lahore in May, 2009 and is planning sequential hypermarket store openings in the main urban population centers in the near future. Each store is frequented by hundreds of consumers daily, with significant buying power. These large supermarket chains, along with future entrants, will significantly change the dynamics of produce marketing in Pakistan. They will create significant domestic market opportunities for those Pakistani growers able to provide the stores with consistent supplies of high quality mangoes. However, growers must be able to meet the quality, packaging, and food safety standards of these large supermarkets in order to establish a market presence.

As a nation's economy grows and buying power increases, consumers typically spend additional amounts of their disposable income on high quality fruits, or value-added fruit products. The Pakistani economy is growing and the increasing amount of disposable income represents a market opportunity for the mango sector.

3.1.2 Export

Although the domestic market is the primary outlet for the vast majority of Pakistani mangoes, development of the export market represents the area with the greatest growth potential. Nevertheless, increasing exports of Pakistani mangoes could have a strong pull-through effect on improving domestic marketing, especially in the supermarket, food service and processing sectors. Currently, the percentage of mango fruit exported in relation to total production is low. Out of the estimated 1.7-1.8 million metric tons of mangoes produced in Pakistan annually, approximately 76,000 metric tons were exported in 2008. This season (2009), the export volume reached a record volume of 132,000 metric tons. Increasing the export volume will have a major impact on the economic value of the crop.

The leading export market destinations for Pakistani mangoes are Dubai, the Gulf States and Saudi Arabia. These countries comprise nearly 80 % of the total export volume. Lesser volumes (~ 15 % of total exports) are exported to the U.K. and several other European countries, including Germany, France, Norway, Denmark, and Switzerland. The majority of mango exports to the E.U. are consumed by expatriate Pakistanis and other Asians living abroad. However, among the native E.U. populace, Pakistani mangoes generally have a reputation of low quality because of poor postharvest care, low quality packaging, and highly variable arrival condition. Singapore, Malaysia, and Hong Kong are the main Far East markets, although this region constitutes only about 1 % of the total export volume.

India is the leading supplier of mangoes to the Middle East markets. The end of their harvest season overlaps with the early harvest months in Pakistan. Although India is a strong competitor, Pakistan has an opportunity to increase market share in the Middle East region by reducing production costs and improving fruit arrival quality. This can be accomplished by adopting improved production practices and better postharvest care. Potential also exists to expand fresh mango exports to the neighboring countries of Iran, Afghanistan, China, and India. The Central Asian republics and Russia also represent growing markets for mangoes. Consumer demand for mangoes in the more developed Asian countries, Europe, and North America has significantly increased during the last 15 years and these destinations also represent significant market opportunities for Pakistani mangoes. Phyto-sanitary requirements currently restrict the exports of Pakistani mangoes to some of the aforementioned market destinations. In the case of China and Iran, both require a hot water treatment; the U.S. requires irradiation, and Japan requires a hot vapor (steam) treatment.

The U.K. and E.U. are large importers of fresh mangoes. In the retail supermarket trade, mangoes have evolved from an exotic item given limited display space to a mainstream fruit featured on a year around basis. The mango market in the U.K. and many E.U. member states has increased during the last 5 years at an annual rate of between 15-20 %. However, due to the global economic crisis, this rate of growth was not achieved during the past year. Recent trends by country in E.U. mango import volumes are shown below.

Table 2: Recent mango import volumes into the E.U.

Country	Import Volume (metric tons)		
	2002	2004	2006
U.K.	24	35	53
Netherlands	31	23	42
Germany	25	30	30
France	17	25	20
Portugal	15	17	15
Spain	5	7	11
Belgium	3	3	5
Total E.U.	133	160	199

Source: Eurostat

In general the high-value fresh produce lines have been suspended in many of the supermarkets. In the case of mangoes, the only exception to this in 2009 has been a “season’s best” line of Maya and Shelley mango cultivars from Israel (300 g minimum weight). The fruit is tree ripened and has excellent flavor. The mangoes are shipped by a sea/truck combination through the Southern European ports to keep the price down. Tesco initially charged a retail price of £1.90 per fruit, but due to limited sales had to reduce the price to £1 per fruit.

Multiple cultivars of mangoes are featured in the leading supermarket chains along with organic, ripe-and-ready pre-packed mangoes, and minimally processed mangoes. There has been a definite shift in consumer preference towards the sweeter, smoother fleshed mangoes and away from the more fibrous, less flavorful Tommy Atkins and Haden cultivars. This bodes well for the Pakistani mango industry, with the large volumes of sweet and smooth-fleshed Sindhri and Chaunsa, and lesser volumes of White Chaunsa. Pakistani mango exporters have a 5-month potential export season to the U.K. and E.U., if Global GAP certification and fruit quality requirements can be met. A realistic objective of the Firms Project should be to facilitate the sustained presence of Pakistani mangoes in the E.U. retail supermarket trade. Successful export penetration of Pakistani mangoes in the North American market is also attainable.

Due to the inconsistent fruit quality upon arrival, Pakistani mangoes are typically relegated to the low-priced secondary wholesale markets in the U.K. and E.U. currently; there is a total absence of Pakistani mangoes in the high-end niche markets and retail supermarkets. The Pakistani mango industry has not established a reputation for high quality product in the international markets. Therefore, this has not put Pakistani exporters in a position of being able to capture high market prices or develop specialty markets. Pakistani producers must be able to differentiate their mangoes over competing suppliers by establishing a reputation for consistency and superior quality

fruit. Pakistan will continue to face increasing competition from other mango supplying countries that are also targeting high value export markets.

Demand for organically-grown produce is increasing and growth in market share is expected into the foreseeable future. Organic fruit and vegetables currently comprise between 2-3% of overall produce sales in most developed countries. Another specialty market of importance to the Pakistani mango sector is the Fair-trade market (supplied by AgroFair, now a Europe-wide company). Like organics, consumer demand for Fair-trade-labeled produce is also increasing in the E.U. Since Fair-trade mangoes were introduced in the U.K. market in 2002, sales have risen at an average annual rate of 57 %. Fair-trade products are grown using cultural practices that protect the environment and use less agro-chemicals, but are not necessarily organic. Workers associated with Fair-trade-certified growing operations typically receive more benefits (health care, social services, bicycle, etc.) and around 20% higher wages. Average retail prices for Fair-trade products are also 10-20% more than conventional items.

A significant positive development in the export market for Pakistani mangoes has been the recent procurement of large volumes of fruit by Metro to supply their stores in Europe. The firm is committed to purchase substantial volumes of fruit in the future to supply their numerous stores (Metro is world's fifth largest food retailer). The firm is actively involved in conducting trials of controlled atmosphere (CA) marine container transport of fresh mangoes to Europe. These trials have been done with the support and cooperation of the Government of Punjab Agriculture Department and the University of Agriculture, Faisalabad. Much has been learned from the 3 trial shipments conducted this year. The initial CA shipment of Sindri mangoes in June from Asam Agricultural Farms arrived with some postharvest decay, but much was learned from this test. The latest 20-foot CA marine container shipment of White Chaunsa from Ali Tareen Farms sent in August arrived in Belgium in excellent shape. However, Diplodia stem end rot and anthracnose developed on the fruit during distribution and marketing in Europe, reducing the amount of marketable fruit. More effective pre-harvest disease control measures are needed in order to reduce the level of Diplodia and anthracnose infection of the fruit. In addition, improvements are needed in the fruit postharvest handling, hot water treatment, interval between harvest and cooling, the rate of field heat removal, and cold chain maintenance during in-land transport. The Firms Project should apply the lessons learned from this year's CA trial shipments and conduct additional CA marine and airfreight shipments to new U.K./E.U. importers in 2010. Several new importers representing the large mainstream retail supermarkets should be selected. Based on recent personal communication with two of the largest U.K. mango importers, significant interest was expressed in receiving trial shipments of Pakistani mangoes for marketing in the mainstream British retail chains of Tesco, Marks & Spencer, and Waitrose.

If successful, CA marine transport would significantly reduce transportation costs versus airfreight. Transport cost is generally the single most important component contributing to the overall export cost of mangoes. A lowered arrival cost for Pakistani mangoes

would allow for a lower retail store price in Europe, increasing the sales volume and making Pakistani mangoes more competitive against other supplying nations.

In North America, per capita consumption continues to increase and mangoes are one of the most rapidly growing fruit import items. This bodes well for potential Pakistani mango exports to the U.S. market in the future. The U.S. is the world's largest importer of mangoes, with a global import market share of about 40 %. It is an affluent nation of 307 million people, with considerable opportunities for high-end niche marketing. The per capita consumption of mangoes in the U.S. has increased three-fold during the last 15 years. Consumption per person increased from 0.67 lb (0.30 kg) in 1992 to 2.09 lb (0.95 kg) in 2006.

Table 3: Fresh mango consumption in the U.S.		
Year	Consumption	
	Total (million pounds)	Per capita (pounds)
1980	57	0.25
1982	67	0.29
1984	102	0.43
1986	117	0.49
1988	92	0.38
1990	134	0.54
1992	173	0.67
1994	255	0.97
1996	361	1.34
1998	412	1.49
2000	495	1.75
2002	569	1.97
2004	592	2.01
2006	628	2.09

Source: U.S.D.A. Foreign Agriculture Service, Washington, D.C.

The U.S. imports over 99 % of the mangoes consumed in the country. The main mango suppliers to the U.S. their export season, and recent export volumes is shown below.

THREE YEAR TRENDS FOR U.S. MANGO IMPORTS BY COUNTRY AND BY MONTH, 2004 - 2006

Top 6 Source Countries Representing 98% Of Imports Into The U.S.

Country	Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Country Total	%
Mexico	2005	0	139	2,588	6,046	6,453	6,205	6,051	5,651	1,855	64	3	0	35,054	61.07%
	2006	0	794	3,473	4,489	6,975	9,986	7,612	5,383	1,064	9	2	0	39,787	62.10%
	2007	0	280	3,215	5,491	6,132	7,969	8,557	6,833	2,032	162	0	0	40,671	61.48%
	AVG	0	404	3,092	5,342	6,520	8,053	7,406	5,956	1,650	78	2	0	38,504	61.57%
Peru	2005	2,610	2,949	818	5	0	0	0	0	0	0	4	196	6,583	11.47%
	2006	2,105	2,933	2,204	63	0	0	0	0	0	0	20	88	7,412	11.57%
	2007	2,515	2,002	805	125	0	0	0	0	0	0	23	946	6,416	9.70%
	AVG	2,410	2,628	1,276	64	0	0	0	0	0	0	16	410	6,803	10.88%
Ecuador	2005	1,149	80	5	0	0	0	0	0	0	113	1,737	2,227	5,310	9.25%
	2006	1,445	134	0	4	3	0	0	0	0	417	2,546	2,303	6,851	10.69%
	2007	1,881	9	0	0	0	0	0	0	0	215	2,046	3,696	7,847	11.86%
	AVG	1,492	74	2	1	1	0	0	0	0	248	2,110	2,742	6,669	10.66%
Brazil	2005	0	50	156	34	0	0	0	162	1,387	2,751	1,201	25	5,765	10.04%
	2006	0	30	132	0	0	0	0	103	1,212	1,566	1,911	138	5,091	7.95%
	2007	92		51	71				656	1,746	2,088	705	21	5,430	8.21%
	AVG	31	26	113	35	0	0	0	307	1,449	2,135	1,272	61	5,429	8.68%
Haiti	2005	43	31	123	605	344	255	619	50	0	0	0	0	2,071	3.61%
	2006	0	0	60	411	860	325	474	116	0	0	1	15	2,264	3.53%
	2007	73	6	79	568	470	665	68	5	0	0	0	0	1,934	2.92%
	AVG	39	12	87	528	558	415	387	57	0	0	0	5	2,089	3.34%
Guatemala	2005	0	0	148	1,033	857	17	0	0	0	0	0	0	2,054	3.58%
	2006	0	0	221	1,138	636	18	0	0	0	0	0	0	2,013	3.14%
	2007	0	0	223	1,604	926	86	0	0	0	0	0	0	2,839	4.29%
	AVG	0	0	197	1,258	806	40	0	0	0	0	0	0	2,302	3.68%
2005 Totals		3,806	3,291	4,028	7,908	7,752	6,495	6,670	5,863	3,242	2,928	2,945	2,469	57,396	100.00%
2006 Totals		3,558	3,957	6,356	6,330	8,521	10,356	8,097	5,602	2,277	1,992	4,480	2,548	64,074	100.00%
2007 Totals		4,574	2,357	4,974	8,099	7,587	8,733	8,641	7,498	3,780	2,471	2,774	4,663	66,150	100.00%
AVG TOTAL		3,980	3,202	5,119	7,445	7,953	8,528	7,802	6,321	3,100	2,463	3,400	3,226	62,540	100.00%
3-Yr Avg %		6.36%	5.12%	8.19%	11.91%	12.72%	13.64%	12.48%	10.11%	4.96%	3.94%	5.44%	5.16%		

Figure 1: Three year trends for U.S. mango imports by country and by month, 2004-2006

Import volume given in 10,000 pound (4,545 kg) units.

Source: U.S.D.A. Foreign Agriculture Service, Washington, D.C.

There is considerable interest within the U.S. market in receiving exotic mango types. During the last several years, mangoes from India, Thailand, and the Philippines have all been exported with success and market demand for these types of mangoes continues to increase. Although the retail price is significantly higher for the Asian mango cultivars, there is considerable buying power and unmet market demand.

Fresh mangoes from Pakistan are currently not allowed in the U.S. due to certain insect pest phytosanitary restrictions. Larvae of fruit flies must be prevented from entering the fruit. The U.S.D.A.-A.P.H.I.S. has a strict protocol to comply with in order to be considered for mango fruit admissibility status into the U.S. This involves monitoring/trapping of the insect pests of quarantine in the field, certification of individual farms and packinghouses, construction of the packinghouses to comply with APHIS requirements, and irradiation treatment of the fruit. Approved transport vehicles will also be necessary in order to prevent hitch-hiker insects from entering the sealed compartment or marine container which holds the fruit. As a condition of entry into U.S., the mangoes must be treated in Pakistan with irradiation by receiving a minimum absorbed dosage of 400 Grays. Importers must obtain a USDA import permit for the scheduled port of entry in advance of arrival of the shipments. In order to reduce the incidence of postharvest decay, the mangoes should be given a hot water fungicidal dip (i.e. thiabendazole at 500 ppm) at 52° C for 3-4 minutes.

Each export consignment of mangoes must be inspected by USDA-APHIS as part of the required pre-clearance inspection activities and be accompanied by a phytosanitary certificate issued by MINFAL. The phytosanitary certificate must bear the following additional declarations confirming that: (1) the mangoes were subjected to postharvest mitigation options described above and (2) the mangoes were inspected during pre-clearance activities and found free of *Cytosphaera mangiferae*, *Macrophoma mangiferae*, and *Xanthomonas campestris*.

The mango orchards involved in the export program to the U.S. must be registered with an APHIS-approved packinghouse facility. The registered orchards must maintain documented record of all operations carried out in the orchard and adopt good agricultural practices for management of mango trees. Each crate of fruits will be labeled/marked indicating the name of orchard/locality, production unit code, cultivar and date/time of harvesting. The packinghouses must ensure that no other fruits or vegetables are processed, while processing mangoes at the facility. The mangoes must be packed in insect-proof cartons. If ventilated boxes are used, all the ventilator openings of the box should be covered with insect-proof screen of a minimum of 30 meshes per linear inch and all the sides of box should be sealed with adhesive tape to prevent any entry of pests. Only packing material of food grade should be used for packing mangoes at the packhouse facility and the cartons should be used for packing export mangoes, as approved by USDA-APHIS.

Before loading the cartons of packed mangoes, the transport vehicle must be carefully inspected to ensure it is clean and free from hitch-hiking pests. At the completion of loading, the doors of the vehicle must be closed, locked, and a suitable seal must be affixed to ensure the integrity of the shipment. The treated lots must be safeguarded in a secured area protected by an insect-proof screened partition to prevent any re-infestation of the treated fruit by hitchhiking pests.

3.1.3 Processed Products

The large and increasing domestic population provides mango agro-processors with solid market growth potential. It is estimated that only about 3 % of the total mango production volume in Pakistan is processed. The main agro-processed product is pulp, which is then used to make nectars, squashes, and drinks. There is a limited amount of agro-processing infrastructure capacity for mango pulp in Pakistan, which is estimated to range between 12,000 to 15,000 metric tons annually. The demand for pulp is estimated to be increasing at the rate of 5 to 10 per cent annually. Additional agro-processed mango products in Pakistan include nectars, squashes, and drinks made from pulp and jam, pickles, and achar. Market expansion of all of these agro-processed products is possible, both domestically and for export. However, improvements will be needed in product consistency, color, and flavor to be successful in the export market. The leading agro-processing firms involved in producing mango pulp, nectar, and squash products include [REDACTED]. The main processors involved in making mango jam [REDACTED]. The leading processing firms involved in producing mango pickles include [REDACTED]. There is no commercial processing of dried mangoes or IQF mango products.

4. Firms Project Mango Sector Activities Recommended for Immediate Implementation

4.1 Export Market Development

Development of high-value and high volume export markets for existing and new value-added mango products should be the underlying objective of the Firms Project mango sector activities. The following markets and products should be given priority during the next 4 years: fresh mangoes for the leading retail supermarkets in Europe, Asia, and North America; mango pulp, nectar, and drinks; dried mangoes; and individual quick frozen (IQF) mango products. All have strong potential for further market development and are lacking or under-represented by Pakistan in the global marketplace. Market linkage activities should begin as soon as possible, linking potential importers/buyers with producers/exporters that are capable of supplying the desired fresh or value-added mango product. An initial market linkage trip is suggested for February, 2010 at Fruit Logistica produce marketing conference in Berlin, Germany. Pre-arranged meetings between potential E.U. importers and Pakistani producers/exporters should be set up in advance of the produce conference to facilitate meeting with as many potential importers as possible. Identification of potential market opportunities will give producers an incentive to invest in the appropriate technologies and infrastructural improvements required to supply the market with high quality mangoes.

4.2 GlobalGAP Certification

GlobalGAP certification of the mango production operation and packing facility is required by all of the major retail supermarkets in the E.U. The high volume retail market channel, specifically the major supermarket chains, constitutes the majority of produce item purchases among consumers in Europe. Therefore, it should be a priority market targeted by the Firms Project. Global GAP certification will also result in improved production and postharvest care practices on the farm and in the packing house, and post harvest benefit the mango operation in terms of better production techniques. The potential export market volume for Pakistani mangoes in Europe is high and it will require substantial acreage and numerous production operations to be Global GAP certified in order to be able to supply the potential volume. Currently, there are only 4 Global GAP certified mango operations in Pakistan, representing slightly more than 1,000 acres of production. These [REDACTED] Progressive Mango Growers Group (PMO) in Multan. The PMO has three mango handling sites certified, including Atta Farid Fruit Farms, [REDACTED] Four additional producers in the Multan and Bahawalpur districts have begun the registration process for GlobalGAP

certification. Grower training in the requirements of GlobalGAP and the in-country certification is done by Bureau Veritas.

Recommendations

The Firms Project should facilitate GlobalGAP certification in 2010 of the 4 newly registered producers. These producers will significantly increase the quantity of mangoes potentially available for the E.U. retail supermarket trade. In addition, the Firms Project should work with the existing GlobalGAP-certified producers to help them increase their export volume. Training and field demonstrations on improved production and postharvest practices should be established on the GlobalGAP-certified farms. The Firms Project should also facilitate the establishment of model packinghouses on these farms. The packinghouses should include de-sapping tanks and drying racks; grading, sorting, and packing tables; a cooling/and cold storage room; a hot water treatment system for postharvest disease control; and an ethylene ripening chamber.

4.3 Support for Additional Testing on CA Transport for E.U. /U.S. Market Penetration

Trial shipments are needed to test the arrival quality and market life of irradiated mangoes shipped by CA marine container to the U.S., or similar shipping distance market destinations. If the results are positive, it will significantly expand the potential export volume of Pakistani mangoes to the U.S. market. Facilitation of the successful penetration of Pakistani mangoes into the U.S. market would be a significant contribution and high profile “home run” for the Firms Project.

4.4 Development of New Value-Added Products

Fresh mangoes can be used to make multiple types of agro-processed products, depending on the maturity stage of the fruit. Green fruit can be used to make chutney, pickles, curries and dehydrated products. Ripe mangoes can be dried, frozen, canned, or made into purée for re-manufacturing into juice, squash, nectar and jam.

4.5 Dried Fruit

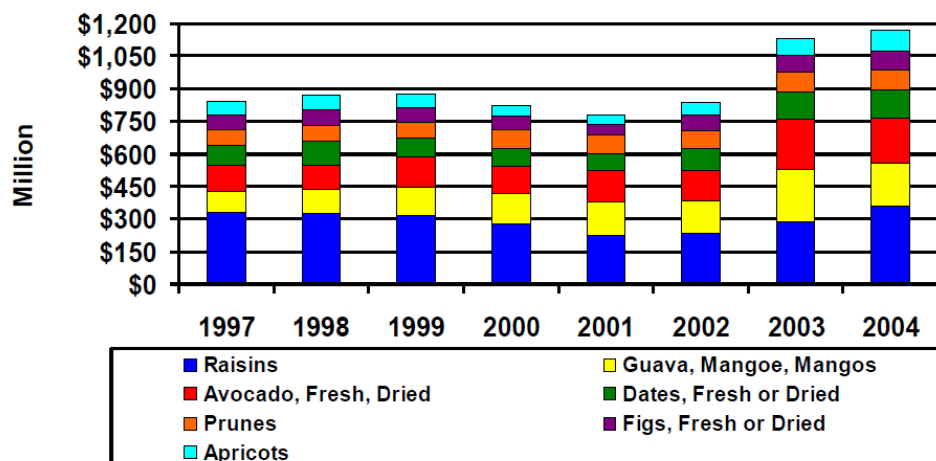
Pakistan is a significant producer of dried fruit and nut products, with raisins and dates being the leading items. Lesser volumes of figs, prunes, apricots, and other dried fruit products are also available. Interestingly, there is no commercial production of dried mango products for either the domestic or export market. This value-added product has significant market potential for use in breakfast cereals (freeze dried pieces) and as snack foods (dried slices). The technology for drying mangoes is not complicated and typically uses solar energy or hot air to heat the inside of the drying structure. Dried mango slices are typically prepared from half-ripe fruits, which are washed, peeled, and cut into 6-8 mm thick slices. In order to obtain a good quality dried mango slice with a long storage life, the fresh slices are soaked in a solution containing boiling water, 40° Brix sugar solution, potassium metabisulphite (preservative), and citric acid (anti-oxidant). Without chemical stabilization or added sugar, color changes (due to both

enzymatic and non-enzymatic browning) and flavor/texture changes can occur. The slices are drained, placed on glycerine-coated aluminium trays, and placed in a solar or forced-air dryer. Careful control of temperature and humidity parameters, as well as drying chamber design, is critical to achieving optimal product quality. The drying is completed when the product has a moisture content of 15%. The dried slices are packed in heat-sealed bags and stored in a dry place. The shelf life of dried mango slices is up to 9 months. Without the use of a preservative, the storage life dried mango slices is relatively short.

This value-added mango product offers significant opportunity for development in Pakistan and should be a priority for Firms Project work activities. Dried product quality, consistency, and packaging all need to be developed. However, considerable information is available and can be adapted to Pakistani conditions. In addition, market development activities and identification of potential domestic and international buyers needs to be initiated. Dried mango for use in fruit bars, muesli, snacks and baby foods has good potential, especially for Europe, which is the world's biggest market for these products. Dried mango products offer significant opportunity for small-scale producers and agro-processors and women to be involved in export marketing. Successful models to follow can be found in the West African nation of Burkina Faso. The initial mango drying units were built in 1980, with the support of various NGOs, to use the excess production and gain access to new markets. The country's dried mango industry now involves about 50 small firms, producing between 600 and 700 metric tons of dried mango for export, generating almost \$5 million in annual revenue.

The leading export markets for dried fruit are the E.U. and U.S. Raisins and mangoes are the leading dried fruits consumed in the E.U. The graph below shows the import value of various dried fruits in the E.U. market.

Import value of dried fruits in the E.U.



Source: Global Trade Atlas

Figure 2: Import value of dried fruits in the E.U.

4.6 Fruit Leathers/Rolls

Mango fruit leathers or rolls are additional value-added dried products with a good domestic market potential. They are simple to prepare, using peeled ripe mango fruit cut into pieces. The pulp is blended and sugar, citric acid, and potassium meta-bisulphite are added until the homogenate contains 25% soluble solids. The pulp is heated for two minutes at 70-80° C. It is then poured into aluminum trays coated with glycerin (this facilitates the removal of the dried pulp). The trays are dried in a forced air or solar dryer. The drying is completed when the product has the consistency of leather (about 15% moisture content). The dried product is then cut into small squares (i.e. 4 X 4 cm). Each square is wrapped in cellophane paper, packed in cellophane bags, and stored in a dry place.

4.7 Individual Quick Frozen (IQF) Products

The Firms Project should also focus on the development of individual quick frozen (IQF) mango products, which have a significant international market demand. Currently, there are no IQF mango agro-processors in Pakistan, although a new company in Siawal will begin operation next year.

4.8 Mango Seed Kernel Butter/Oil

The mango kernel is not being utilized to its full commercial potential. An average mango kernel contains about 8% to 15% extract potential (butter and oil). The fat from

the mango seed (kernel) can be used as an animal fat and/or cocoa butter substitute in soups and confectionery products. It can also be used as an ingredient in soap, skin creams, suncare balms, haircare products, and cosmetics. Dermatologists recommend mango kernel oil to protect against ultraviolet radiation, to clear blemishes and wrinkles, and to treat skin disorders like eczema. Besides this, it effectively treats dry skin, skin allergies, skin peeling and prevents stretch marks.

The seeds of different mango cultivars differ in the amount and quality of their fat/oil. This will affect the economics of production and use of the extracted fat/oil. On a dry weight basis, the fat content in the kernel portion of the mango seed may be as low as 4 % in some cultivars and as high as 12 % in others. In addition, the individual fatty acid composition of the kernel varies widely between cultivars. Mango kernel extracts typically receive a price premium in the cosmetic, wellness, and beauty industries.

4.9 Animal Feed

Mango seed meal can be used as an ingredient in animal feeds. The cake remaining after extraction of the kernel oil can be used as a substitute for wheat and maize flour in animal feeds and is a good source of many essential amino acids.

4.10 Pectin

The pectin obtained from the mango peel is comparable to the pectin from citrus fruit. Mango pectin can be used in making jams, jellies, marmalades, and pharmaceuticals.

Appendix 2- Principal U.K./E.U. Mango Importers

The following companies are the leading importers of tropical fruit and specialty vegetables in the U.K. They are the suppliers of fresh produce to the large retail supermarket chain stores. Their product line includes year-round offerings of numerous items, including mangoes, citrus, specialty vegetables, and herbs.

Utopia UK Ltd.

Enterprise Way, Pinchbeck, Spalding, Lincolnshire PE11 3YR UK

Telephone: XXXXXXXX

Utopia UK Limited is a leading importer and supplier of exotic fresh produce to the leading U.K. supermarkets. The company imports over 60 different fresh fruit and vegetable products from 37 supplying countries. It has recently expanded fresh produce import into the continental European retail market.

Minor, Weir & Willis Ltd.

241 Wellington Road Perry Barr Birmingham B20 2QQ

Minor, Weir & Willis (MWW) is one of the U.K.'s largest importers and suppliers of fresh produce to the retail trade. The company sources over 100 products from more than 40 countries. The company is headquartered in Birmingham, with affiliated companies in Spain, the Netherlands, and Germany for sale of fresh produce from around the world to retailers in the U.K. and continental Europe.

Wealmoor

Jehta House, Springfield Road Hayes, Middlesex, UB4 0JT

Wealmoor is the U.K.'s largest mango importer and also supplies a wide diversity of fruit and vegetables to the leading retail supermarkets. The company is headquartered in London, near Heathrow airport. It also markets product throughout Europe.

Malet Azoulay Ltd.

West Marsh Road

PE 11 2BD Spalding, Lincolnshire

Malet Azoulay is a leading importer of fresh and dried mangoes in the U.K. They currently supply Marks & Spencer and Waitrose supermarket chains. They have recently joined the UniVeg family of companies in Europe.

UniVeg

Strijbroek 10 2860 Sint-Katelijne-Waver Belgium

UniVeg is one of the largest fresh produce distributors in the world and is a leading importer of mangoes in the E.U. UniVeg has grown through internal growth and acquisitions such as Bakker Barendrecht, the Bocchi group, the Katopé group, and most recently Atlanta and Alara. They supply a diversity of fresh produce items to the large retail supermarket chain stores, mostly in Belgium, the Netherlands, and Germany.

Principal Fruit and Vegetable Wholesale Markets in London

The city of London has three main wholesale produce markets, located in different boroughs. The U.K.'s largest fruit and vegetable market is the New Spitalfields Market, located in Leyton. It is the home of approximately 95 fresh produce merchants, with over 60 % of the traders sourcing exotic fruits and vegetables from sources in Asia, Africa, and the Caribbean.

New Spitalfields Market
17 Sherrin Road London, E10 5

The second leading wholesale market is the New Covent Garden Market, located in the Vauxhall area. This market is the leading supplier of fresh produce to the foodservice sector in London. New Covent Garden supplies 40 per cent of the fruit and vegetables eaten on plates out of the home in London.

New Covent Garden Market
Covent House
London SW8 5NX

The third large wholesale market in London is the Western International Market, located in the Hounslow area near Heathrow airport. It is serviced by approximately 75 merchants who supply product to the independent retailers and ethnic market stores.

Western International Market
8 Market Centre, Hayes Road Southall, Middlesex UB2 5XJ Telephone: 44-208-573-5624

Principal Retail Supermarkets in the U.K.

The majority of the fresh fruit and vegetable volume marketed in the U.K. is through the retail sector. The top 4 supermarket chains account for nearly 75 % of all fresh produce sales in the country, according to the industry trade monitoring firm TNS World panel. These four chains are Tesco, Asda, Sainsbury's, and Morrison's. The next three supermarket chains (Co-op, Waitrose, Marks & Spencer) control an additional 18 % of the retail sector produce trade. Therefore, over 90 % of the retail sector fresh produce marketed in the U.K. is through the top 7 supermarkets chains.

Tesco

Tesco is the largest British supermarket retailer. It has held the leading position in terms of market share among British retailers for a number of years. It is also a leading international retailer, with stores throughout Europe, Asia and the U.S. Tesco operates over 2,300 stores worldwide, of which over 1,800 are in the UK. The stores cover a range of formats, the main ones being supermarkets and convenience stores. Tesco controls slightly over 30 % of the British retail supermarket trade, according to TNS World panel.

Asda

Asda is the second leading U.K. supermarket chain, with nearly 340 stores throughout the U.K. It was acquired by the world's biggest retailer, U.S.-based Wal-Mart, in June 1999. It has an approximate 17 % share of the overall British retail supermarket trade.

Sainsburys

Sainsburys is the third leading U.K. supermarket chain, operating nearly 500 supermarkets and an additional 300 convenience stores throughout the U.K. It has approximately 16 % of the U.K. retail supermarket trade.

Morrisons

Morrisons is the fourth leading British supermarket chain, operating over 400 stores throughout the U.K. It has approximately 11 % of the U.K. retail supermarket trade.

Co-op

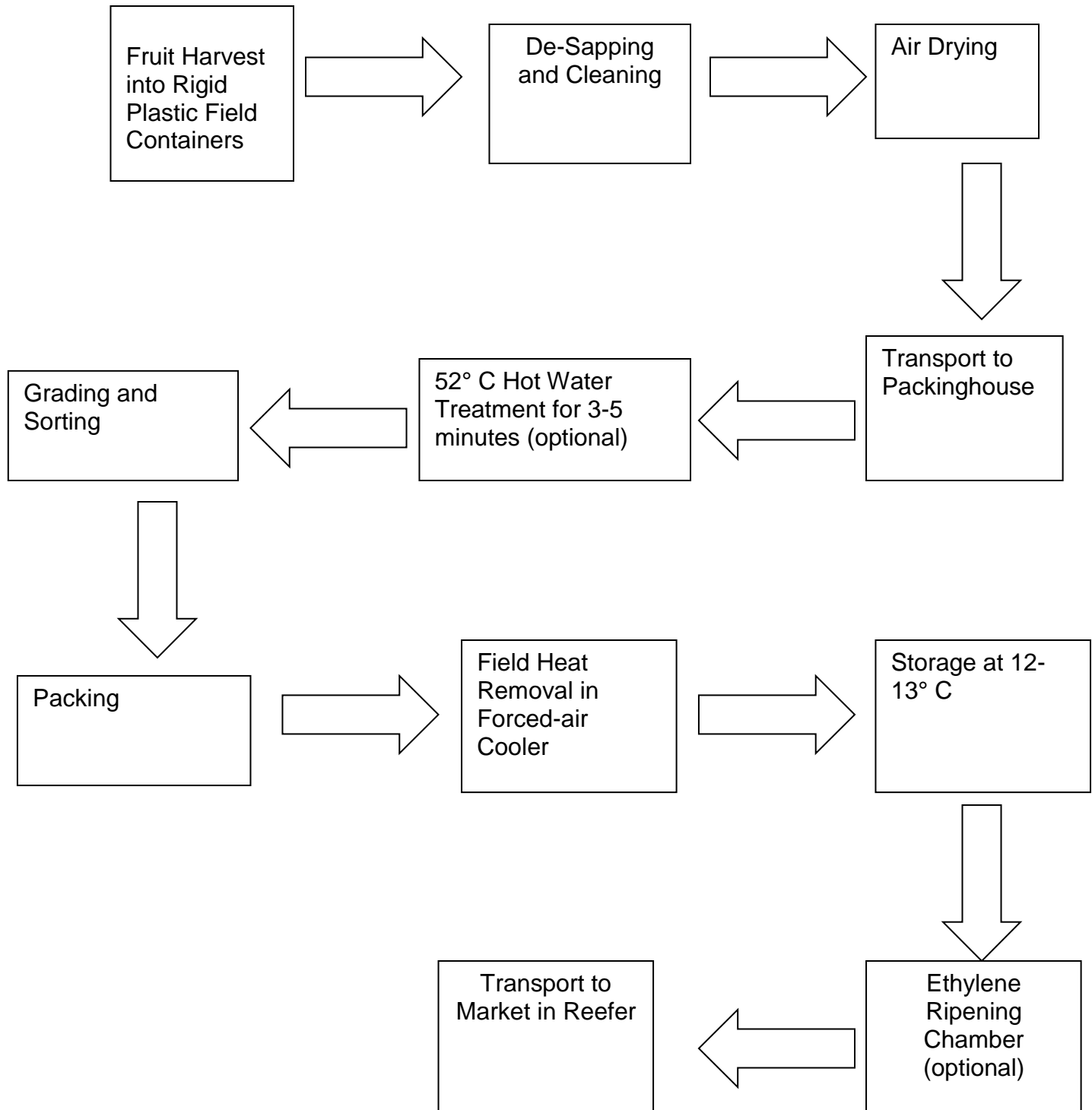
The Cooperative Group (Co-op) is the fifth largest food retailer in the U.K. The firm acquired the supermarket chain Somerfield in 2008 and maintains an approximate 8 % market share. Co-op operates mostly convenience stores and small supermarkets.

Waitrose

Waitrose is the sixth most important British supermarket retailer, with about 180 stores and an approximate 6 % U.K. retail supermarket share. It targets the upper-end income shopper and many stores have an extensive organic produce section.

Marks & Spencer

Marks & Spencer is in seventh position among U.K. supermarket retailers, operating approximately 600 stores throughout the U.K. and maintaining about 4 % of the U.K. retail supermarket trade. Although the fresh produce section of M & S stores is typically much smaller than other retailers, the firm is regarded by many shoppers as the U.K.'s premium quality supermarket chain. Also, unlike other supermarkets, all Marks & Spencer's products are their own brand.

Appendix 3- Flow chart for postharvest handling of mangoes

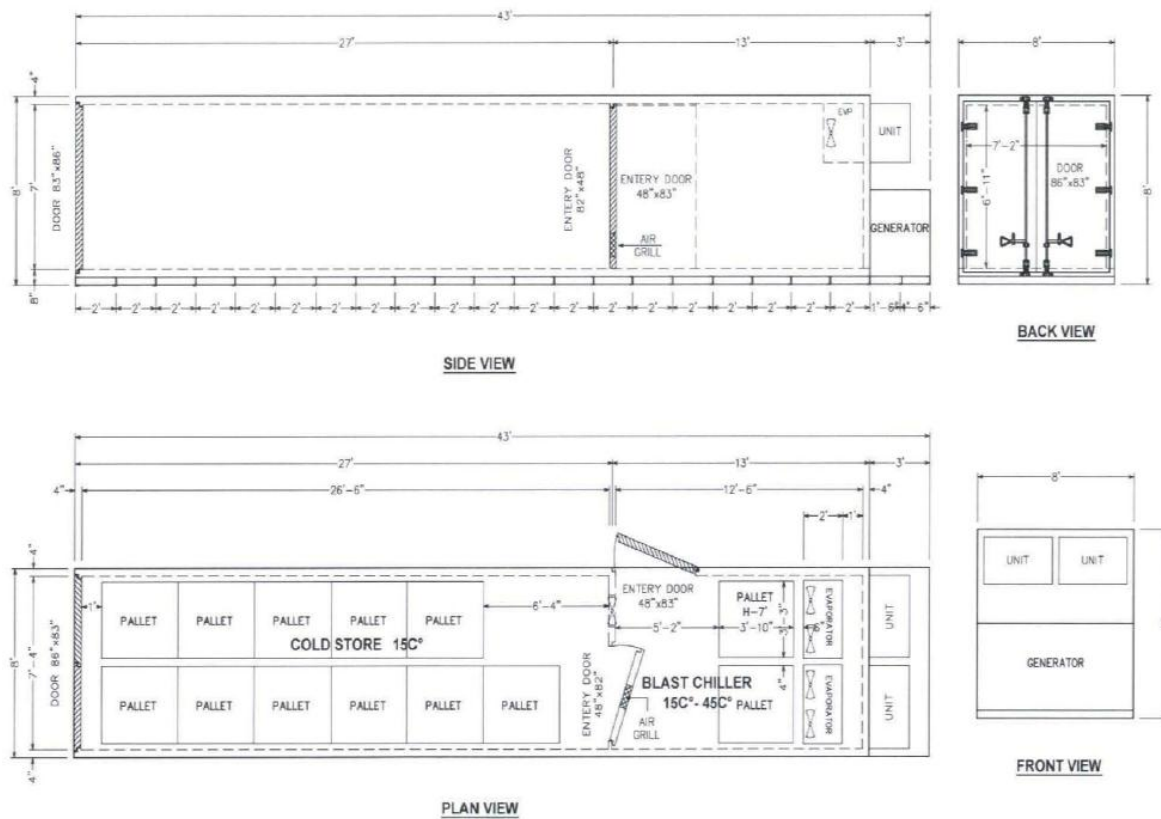
Appendix 4- Cost of packinghouse infrastructure

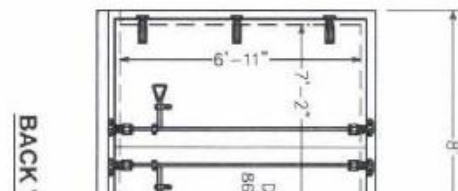
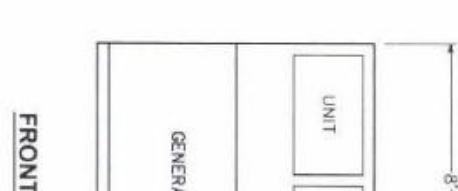
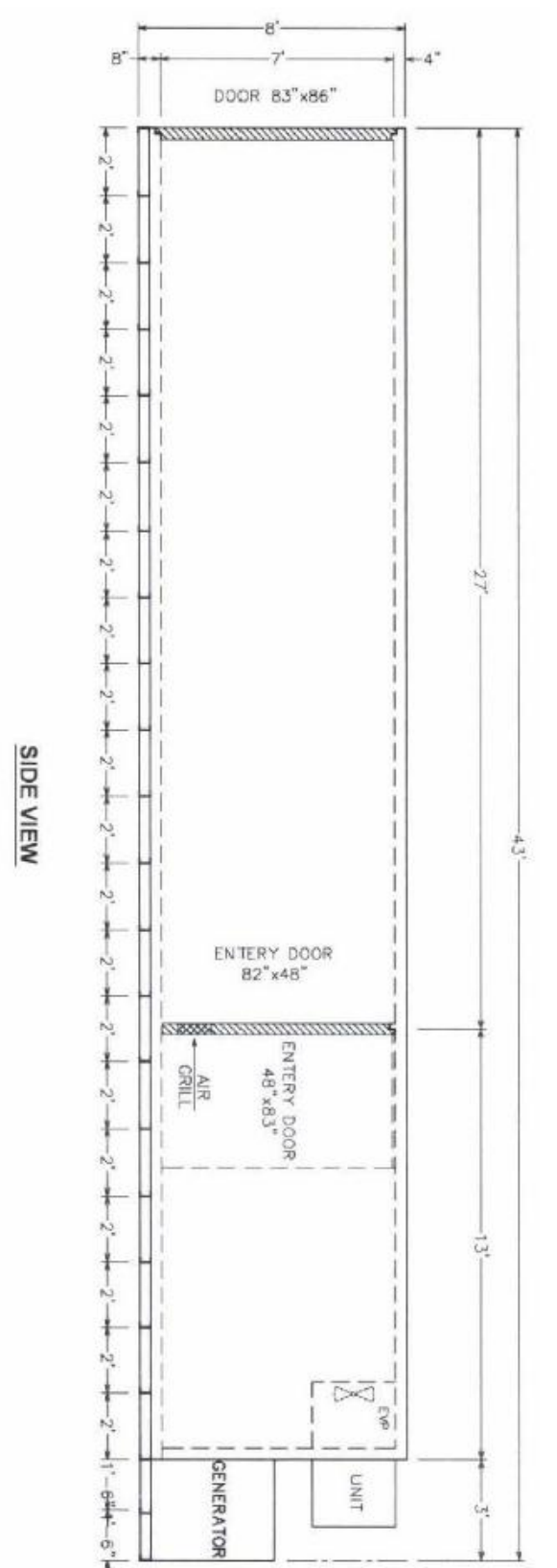
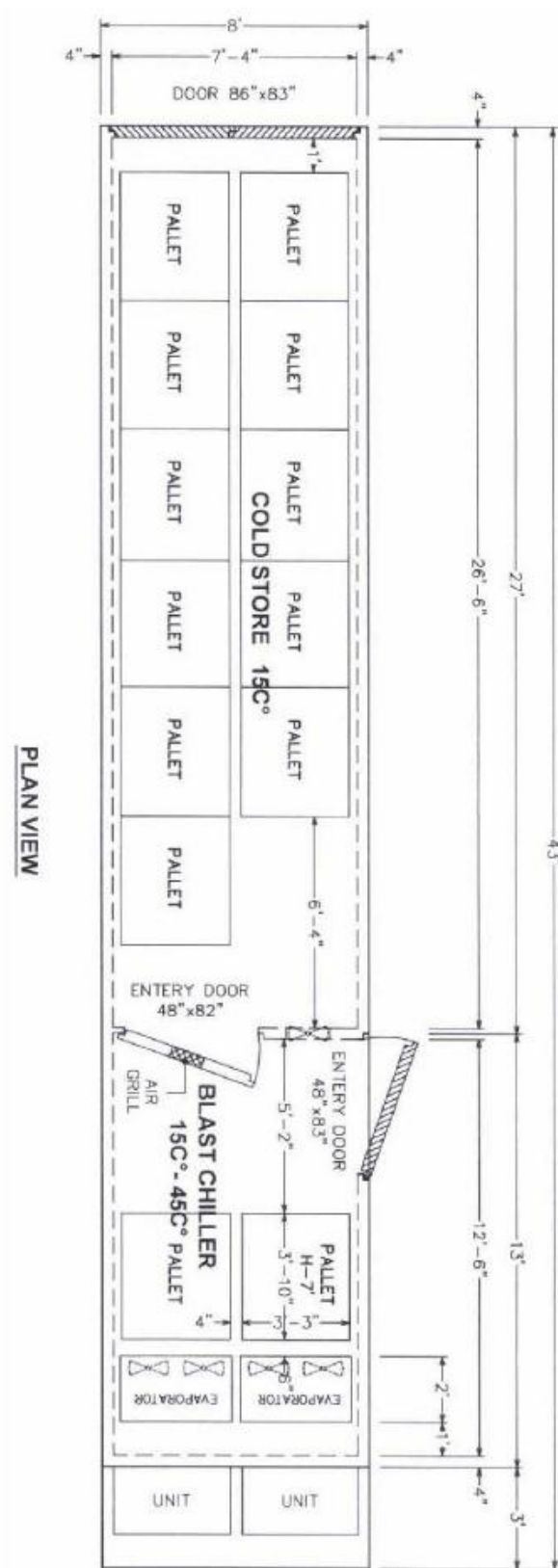
The estimated cost of an on-farm packinghouse and infrastructure to pack and cool 11 metric tons of mangoes per day is approximately 8,900,000 Rs. This includes the building and all the necessary equipment for de-sapping, cleaning, sorting, grading, packing, and cooling. It includes a blast chiller having the capacity to cool 2 metric tons of mangoes in 2 hours, from a pulp temperature of 43° C to 13° C, and a cold storage area with the capacity to store 11 tons at 13° C. The combination blast chiller and refrigerated storage unit (43 x 8 x 8 feet) by itself costs approximately 3,900,000 Rs. This includes a 50 horsepower, 3-phase, diesel-fueled, 380-400 volt generator.

The cost of the hot water treatment unit for disease control is not included in the 8,900,000 Rs amount, and would cost an additional 2,500,000 Rs. An ethylene generator for ripening mango fruit is also not included, and would cost an additional 800,000 Rs. Therefore, the total cost of an on-farm packinghouse which includes the building and all the necessary equipment for de-sapping, cleaning, sorting, grading, packing, cooling, hot water fungal treatment, and ethylene ripening chamber would be approximately 12,200,000 Rs.

Table 4: Itemized cost for the postharvest infrastructure (building and equipment) (in Rs).	
De-sapping and wash tanks	700, 000
Packinghouse building ≥ 800 m ² area with concrete floor and accessories	3,300,000
Sorting and grading tables	1,000,000
Hot water treatment unit (optional)	2,500,000
Blast chiller and cold storage chamber (combination type)	3,900,000
Ethylene generator (optional)	800,000
Total Cost (without hot water unit and ethylene chamber)	8,900,000
Total Cost (with hot water unit and ethylene chamber)	12,200,000

Appendix 5- Schematic design of an 11-ton per day cooling/cold storage facility





Appendix 6- Illustrations of 4-kg corrugated cartons used exporting mangoes to the E.U.

Appendix 7- Suggested Future Work Activities for David Picha

(November 15, 2009- April 15, 2010)

- Arrange program, identify speakers, and invite E.U. mango buyers for international mango workshop in Multan in early 2010.
- Follow-up technical assignment visit, including participation in Multan Mango Workshop.
- Design mango packinghouse facility, including specifications for all components.
- Design on-farm hot water treatment facility for reducing postharvest mango decay.
- Design on-farm ethylene ripening chamber.
- Write mango technical publications.
- Offer sector strategy input/technical assistance to additional fruit and vegetable crop value chains to be prioritized in the Firms Project.

Appendix 8- Future Horticulture Crop Analyses Activities

In addition to mangoes, other high value horticultural crops should also be targeted for development under the Firms Project. The horticulture sector represents one of the greatest potential sources of economic growth in the country. The characteristic high value per unit area of horticultural crop production is particularly important to those areas where available land for cultivation is limited. A largely unskilled but adequate workforce is generally available to perform the numerous production practices and harvesting requirements of the labor-intensive horticulture sector. Further development of fruit and vegetable crop production and value-added products in Pakistan will result in increased rural income, enhanced employment, and a positive economic impact among the relatively poor segment of the population.

Pakistan has a wide range of micro-climates suitable for production of nearly all temperate, sub-tropical, and tropical horticultural crops. Fruits, vegetables, and floriculture crops all have significantly higher export value than the traditional agricultural crops of wheat, rice, cotton, and sugarcane. In order to strengthen the agriculture export sector of Pakistan, it is highly recommended to diversify the portfolio of horticultural crops and their value-added products produced within the Project's 29 targeted districts. Some of these crops are not yet cultivated in Pakistan, but have excellent opportunities for development due to a strong market demand. In some cases, these crops will have more of a demand in the export market than domestically. Examples of additional horticultural crops which all have excellent market potential, both domestically and for export, include seedless citrus fruit (i.e. satsumas, clementines, oranges, grapefruit), fresh dates (e.g. premium quality soft date cultivars like „Medjool“), early-season seedless table grapes, pomegranates, apricots, peaches, nectarines, olives, almonds, litchis, cherries, raspberries, blueberries, strawberries, seedless watermelons, and winter-season vegetables produced inside protected structures.

Work should soon begin to establish market linkages between potential suppliers of these crops and potential buyers. This can be facilitated by pre-arranged meetings with key Pakistani exporters and potential suppliers at the upcoming Fruit Logistica horticulture trade exposition (Berlin, Germany; February, 2010). The market linkage work should also be complemented with focused Project interventions to remove the weak links in the supply chain (i.e. production, harvesting, postharvest care, and transportation constraints). This will require the adoption of improved production and postharvest technologies, worker training, and crop specific technical assistance.

